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USE OF WATER TABLE REGRESSION MODELS, ELECTRODE POTENTIALS, AND SOIL PROPERTIES TO EXPLAIN SOIL FORMING PROCESSES IN AND BETWEEN AN ARTIFICIALLY DRAINED AND UNDRAINED CLARION TOPOSEQUENCE

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and soil properties to explain soil forming processes

in and between an artificially drained

and undrained Clarion toposequence

by

Harry Rudolph James

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GENERAL INTRODUCTION

Genetic pathways among and between members of the Clarion toposequence have been investigated but there still remains a need for a better understanding of soil-landscape relationships for these soils. Although research has established a relationship between topographic position, moisture, temperature, and associated physical and chemical weathering environments, little is known about the quantitative relationship of water tables within and between individual members of the Clarion toposequence.

Soil forming processes among several members of the Clarion toposequence are either directly or indirectly influenced by water table fluctuations. Not only is depth and duration of water table important in determining genetic pathways but an equally important factor of oxygenated water versus stagnant water must be considered. Additions, removals, transfers, transformation processes, and subsequent classification into Soil Taxonomy reflect moisture regimes of soils and landscape.

Depth and duration of water tables among members of the Clarion toposequence vary widely. These water table fluctuations play an important role in making soil management decisions, such as installation of artificial drainage, and land use decisions. For example, interpretations such as rating soils for dwellings with basements or rating soils for septic tank absorption fields are influenced by depth and duration of water tables.

A soil scientist's expertise in being able to recognize and to interpret accurately inherent soil properties has been the basis for grouping soils into natural drainage classes. Soil drainage classes were defined on the basis of removal of water from the soil profile, presence of a water table, and qualitative morphological characteristics. The Soil Survey Staff (1951) integrated these effects into seven natural drainage classes. Since these soil drainage classes describe internal soil water conditions under which soils form, they reflect genetic pathways.

In Soil Survey Staff (1975b), moisture regimes are defined in terms of ground water levels and the presence or absence of water held at a tension of less than 15 bars.

It is difficult to relate soil drainage classes to Soil Taxonomy. In many cases they do not relate well to aquic and udic moisture regimes. Soil drainage classes have been refined over the years based on experience to some extent. For example, the correlation between somewhat poorly drained soils and Soil Survey Staff (1975b) terminology, expecially in transition and forested soils, is very poor. Most of these soils will classify as Ochraqualfs, leaving very little room for somewhat poorly drained criteria.

The Clarion toposequence, which is predominantly composed of Clarion, Nicollet, and Webster soil series, is mapped in an area that covers nearly one fifth of Iowa. Geologically, this area in Iowa that covers approximately 5,000 square hectares is known as the Des Moines lobe (Figure 1).

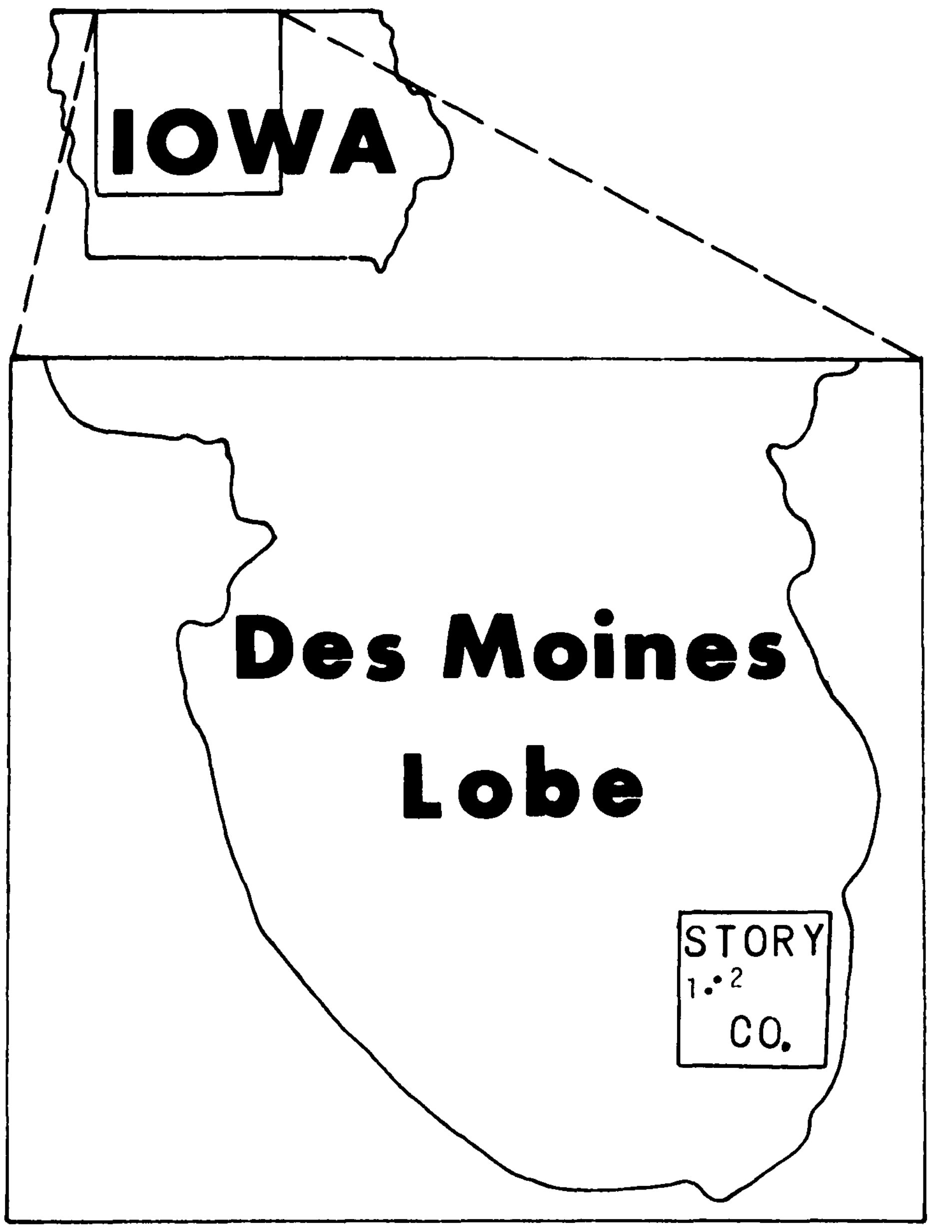

Figure 1. Map of the Des Moines lobe, after Ruhe (1969); the two study areas, identified as No. 1 and No. 2, are located within Story County, Iowa

Subsequent to settlement some 80 to 100 years ago, much of the Des Moines glacial lobe has been artificially drained. In a few years, most of the remaining undrained areas will be subjected to artificial drainage. Therefore, soil forming processes for these drained soils have been altered. What effect has an "artificially drained environment" had on natural drainage classes, water table depths, and morphology among the somewhat poorly, poorly, and very poorly drained members of this toposequence? Has an artificially drained environment changed the relationship between presence or absence of oxygen in capillary water and its effect on soil morphology among members of the Clarion toposequence?

The three general objectives of this study are as follows:

1. To investigate water table relationships along undrained and drained traverses for members of the Clarion toposequence and to develop mathematical water table prediction equations for each site and each traverse,
2. To determine differences in percent clay and total phosphorus distribution for all soils in the tile drained and undrained traverses, and
3. To measure in situ electrode potential and to estimate chemical weathering environments for all soils in tile drained and undrained traverses.

In order to study these problems, one undrained and one artificially tile drained traverse of the Clarion toposequence were selected. These study areas were located in central Iowa on the Des Moines lobe (Figure 1).

GENERAL BACKGROUND

Development of the Clarion Toposequence

A classic study by Milne (1936) in East Africa several decades ago resulted in a concept that appears to fit the Clarion toposequence in the Des Moines lobe of the Cary drift area. His catena concept stated that there is a definite correlation between topographic position and soil individuals. For example, given a set of physiographic conditions such as an undulating or hummocky topography, a specific pattern of changing soil profiles is repeated; that is, from the crest of a low hill to the floor of the adjacent swamp, soil profile characteristics change from position to position on this hillslope according to conditions of soil drainage and modification of land surface during development. Differential transport and redeposition of eroded surficial material, leaching, translocation, and redeposition of mobile chemical constituents must also be considered. Thus, a soil individual is an integration of these forementioned soil forming processes.

A more recent approach to studying and understanding soil genesis was reported by Simonson (1959). Although his concept included some of Milne's (1936) ideas, he further refined soil genesis as an overlapping two-step process. The first step dealt with parent material depositional processes while the more important second step was responsible for horizonation. He further stated that an integration of additions, removals, transfers, and transformation processes produced soil horizon differentiation. Thus, it seems logical that differences in balances among these processes were responsible for developing different and unique soil profiles. Simonson (1959) further stated that Dokuchaiev's classic soil forming factors of climate and vegetation acting on parent material as conditioned by relief over periods of time merely set the stage for soil profile differentiation.

A critical review of literature relating the Clarion toposequence to the concepts of Milne (1936) and Simonson (1959) is basic for understanding this study. Therefore, the following addresses this problem.

Climate

Climate in Iowa, as described by Reed (1941) was considered to be an extreme midcontinental type, that is, prolonged periods of high temperatures accompanied by hot winds occur during the summer months, with winter usually being considered the dry season. Meldrum et al. (1941) also characterized the climate in Story County as continental with wide fluctuations in temperature and rainfall.

A summary of monthly means of temperatures and precipitation for the Ames area as reported by the U.S. Weather Bureau (1960) is shown in Table 1.

During the period from April 30 to October 10 the relative humidity averages about 70% with August being the most humid month. Highest total incoming solar radiation occurs in mid-summer; this is four times the amount received in December.

Most precipitation occurs during the months of April through September. This amount averages 72% of the total. Forty of the 47 thunderstorm days occur during a 5-month period from May through September.

Table 1. Monthly means of temperature and precipitation for the Ames, Iowa U.S. Weather Bureau station, 1931-60

Month or year	Mean temperature (^{o}C)	Mean precipitation (cm)
January	- 6.7	2.7
February	- 4.5	2.5
March	1.2	4.8
April	9.5	6.6
May	10.3	10.9
June	21.2	13.2
July	23.8	8.4
August	22.6	9.8
September	17.9	8.4
October	11.8	5.1
November	2.6	4.1
December	- 3.8	2.6
Year	--	79.1

Occasionally, a drought of some degree occurs in July and August following the precipitation peak. The probability of receiving 2.5 cm of rain in one week decreases from one week in two in early June to one week in four in late July and August.

Ruhe et al. (1957) reported that climate associated with the Des Moines lobe has fluctuated during the last 13,000 years, but that conditions similar to today's climate can be traced back 3,000 years. Thus, soils such as Clarion, Nicollet, and Webster have formed in a climate similar to the present one.

Time

To study the chronology of the Des Moines lobe, samples of organic materials for radiocarbon dates were taken at strategic positions by Ruhe and Scholtes (1956). Their dates showed that termination of the youngest glacial deposit of Iowa, which is named the Des Moines lobe of the Cary drift, occurred about 13,000 years ago. Ruhe (1969) reported radiocarbon dates ranging from 11,952 ± 500 years to 14,042 ± 1,000 years from samples collected from Story County. Therefore, no soils on the Des Moines lobe are older than these dates. Walker (1966) stated that features found in soils common to the Des Moines lobe such as Clarion, Nicollet, Webster, and Okoboji have formed during the last 3,000 years.

Vegetation

Oschwald et al. (1965) reported that soils common to the Des Moines lobe, namely, Clarion, Nicollet, and Webster, developed under a prairie grass vegetation. Research by Walker (1965) showed that vegetation on the Des Moines lobe has not remained constant during the last 13,000 years. For example, pollen data collected from the Colo bog showed that conifer species dominated the landscape for a significant portion of time. Both authors concluded that a prairie grass environment comparable to the present has dominated the Des Moines lobe for the past 3,000 years and that the Clarion toposequence developed under a prairie grass vegetation.

Parent material

Simonson et al. (1952) reported that parent material of the Clarion toposequence consists of a loam-textured, calcareous glacial till with mixed mineralogy.

Topography and relief of study area

Topography of the Clarion-Webster soils area as reported by Simonson et al. (1952) and Oschwald et al. (1965) is characterized as mostly undulating and level. Although there are some hilly areas scattered throughout the Des Moines lobe of the Cary drift, most of the area consists of low knobs and associated shallow, somewhat circular depressions. Surface drainage consists of a poorly integrated system where rain water collects in these shallow basins. Ruhe (1969) concurred with these authors in describing the topography of the Clarion-Webster soils area and further described topographical conditions of the present day Bemis system as consisting of numerous ridges that are convex toward the edge of the lobe. They form intricate patterns that loop and cut across each other.

In Story County, Gwynne (1941) and Ruhe (1969) reported that several of these parallel ridges occur on the landscape in a southwest to northeast direction. These ridges typically have a low relief of 1.6 to 3.1 meters and presumably mark the yearly margin of ice retreat.

Gwynne (1941) reported that aerial photos of Story County, Iowa, showed many alternating light and dark streaks that were interpreted as topographic differences on the landscape. Gwynne soon realized that the light colored streaks could be equated with slightly elevated portions or swell positions of the landscape while the darker counterparts were associated with adjacent depressional or swale areas. In Story County, these streaks average about 15 per 1.6 km. Color differences could be related to differences in soil texture and organic matter content, that is, the dark colored streaks could be associated with areas containing larger amounts of organic matter while the lighter colored streaks could contain lesser amounts.

In the soil survey report by Meldrum et al. (1941), the topography of Story County was described as basically undulating with swales and shallow circular shaped swells dispersed throughout the low ridges. Surface drainage, except in the vicinity of major streams such as the Skunk River, is almost nonexistent. Surface water for the most part collects in shallow depressions and evaporates or is removed by tile drainage.

<u>Modification of topography</u>

Several scientists (Wallace, 1961; Wallace and Handy, 1961; Walker, 1965) concluded that erosion of the Des Moines lobe of the Cary drift subseqest to deposition has modified the original landscape. For example, Wallace (1961) reported as much as 6.1 meters of surficial sediment can be found in some depressions. Wallace and Handy (1961) reported that stone lines on the Cary till are commonly found and that they are associated with filling of depressions with surficial sediments. Additional research by Walker (1966) on five bog watersheds located along a north-south axis of the Des Moines lobe substantiated that erosion of surficial sediments along the slope profile and subsequent deposition of these sediments in a depository had occurred. For example, Walker (1966) reported that the Colo bog which is located in Story County, contained 6.4 meters of surficial sediment. The sediment was removed from hillslopes during a period of approximately 10,000 years. Hillslope erosion was not constant but varied from 0.2 cm/1000 years to as much as 13.7 cm/1000 years during this period.

Ruhe (1969) showed that two major erosion cycles, namely, the Jewell cycle from 3,000 to 7,000 and the Colo cycle from 7,000 to 13,000 years before present, have modified the original Cary Till surface as shown in Figure 2.

Soilscape-sediment-hillslope relations within a closed system in the Des Moines lobe of the Cary drift

Walker (1965) showed that geomorphic surfaces on the Des Moines lobe of the Cary drift have been adjusted to latest increments of hillside erosion. This resulting final landscape has been called the "late post-Cary surface." Major differences among and between soils developed on these geomorphic surfaces were due to differences in drainage and associated sedimentary variations. Within a closed system, surficial sediments showed a distinct and predictable pattern of becoming progressively finer textured, thicker, and better sorted from the hillslope crest to the common depository. Walker and Ruhe (1968) further stated that, within a closed hillslope system, a real systematic pattern occurs between sediment properties and associated soils. An illustration of this relationship is shown in Figure 3.

Classification and Major Characteristics of Soil Series in the Study Area

Clarion

The Clarion series was established in Hamilton County, Iowa in 1917 (Soil Survey Staff, 1976a). It is classified as a fine-loamy, mixed, mesic, Typic Hapludoll (Soil Survey Staff, 1975b). Solum thickness is between 64 and 102 cm but can be found to vary from 46 to 127 cm.

The A horizon is typically 43 cm thick while the B horizon averages

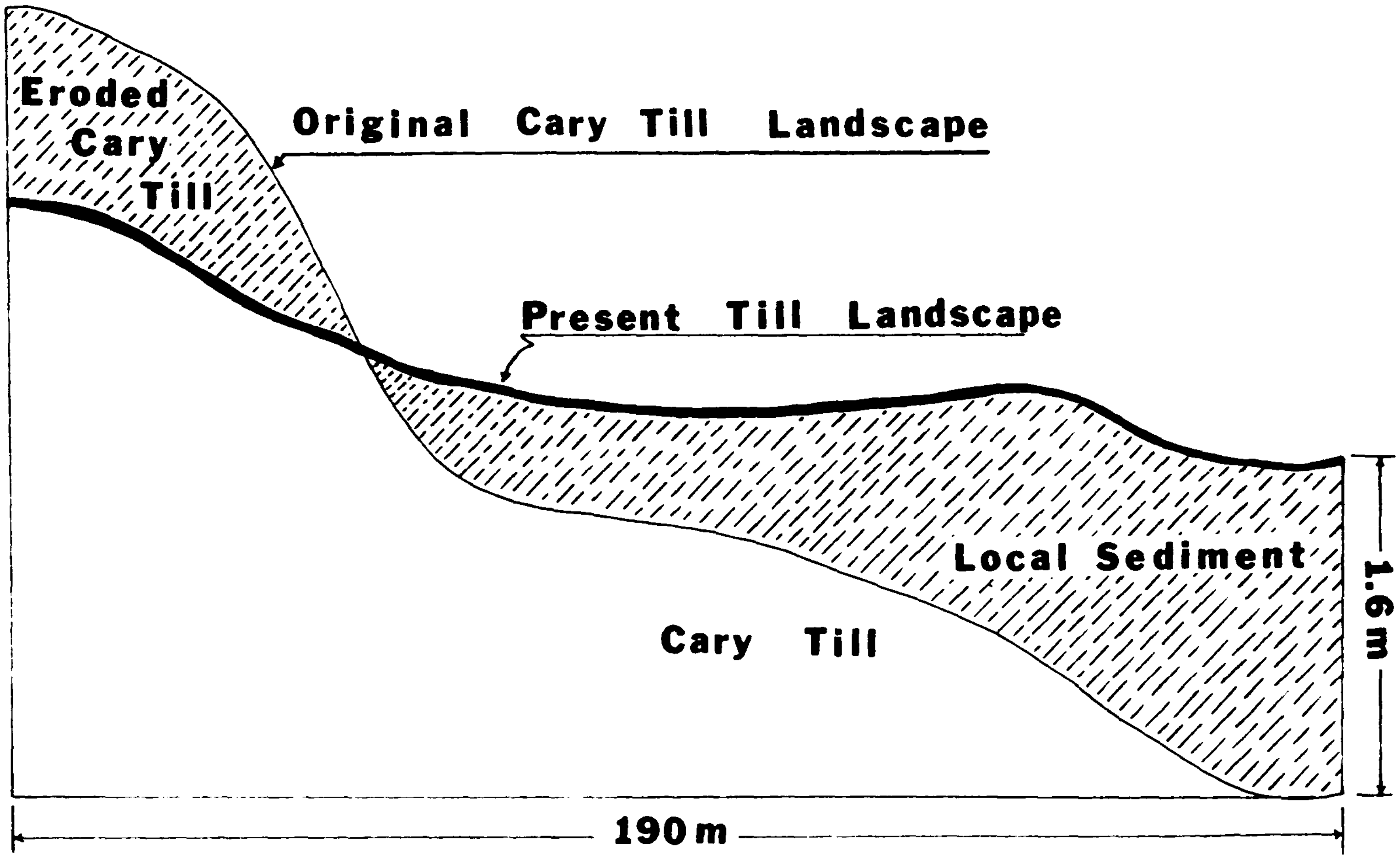

Figure 2. Illustration showing relative modification of Des Moines lobe landscape during a time period from 14,000 to 3,000 years before present

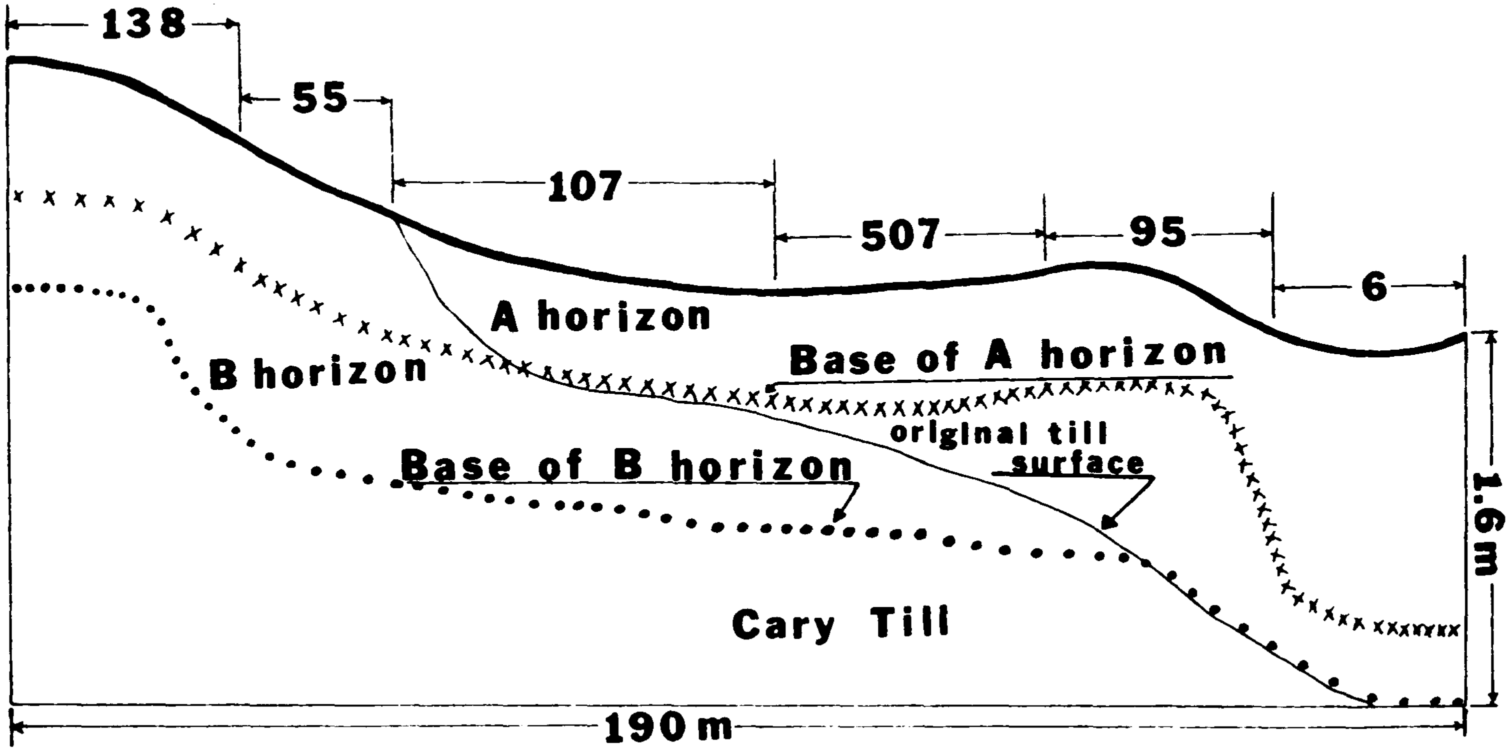

Figure 3. Illustration showing relative landscape position of individual members in the present Clarion toposequence [138 = Clarion, 55 = Nicollet, 107 = Webster, 507 = Canisteo, 95 = Harps, 6 = Okoboji, (▬) = present day landscape surface, and (—) = original till surface (after Walker, 1966)]

38 cm but ranges from 25 to 76 cm in thickness. Depth to free carbonate is about 81 cm. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The B horizon has hue of 10YR, value of 3, 4, or 5, and chroma of 3 or 4 and is free of or nearly free of mottles. The C horizon has hue of 10YR, value of 5, and chroma of 4 or 5. The lower C horizon can have hue of 5Y, value of 5 and chroma of 4. Mottles with hue of 10YR and 7.5 YR, value of 4, 5, or 6, chroma of 2, 3, and 4 are common.

Texture of the A horizon is loam but sandy loam, silt loam, and light clay loam are permitted. The B horizon is either loam or light clay loam texture. Typically, the C horizon is loam but often is a sandy loam. Clay percent in the 25 to 102 cm control section averages between 18 and 28%.

Clarion is well drained, has moderate permeability, and occurs on convex slopes.

Nicollet

The Nicollet series was established in Nicollet County, Minnesota in 1949 (Soil Survey Staff, 1976b). It is classified as a fine-loamy, mixed, mesic, Aquic Hapludoll (Soil Survey Staff, 1975b). Solum thickness is between 51 and 122 cm.

The A horizon is typically 43 cm thick while the B horizon is 48 cm thick. Thickness of solum and depth of free carbonates coincide. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The upper B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 through 4. C horizon color is typically a hue of 2.5Y or 5Y, value of 5, and chroma of 2, 3, or 4. Mottles with hue of 2.5Y and 7.5YR, value of 4 or 5, chroma of 2, 3, and 4 are in the B horizon. Mottles with hue of 10YR and 2.5Y, value of 5, and chroma of 4 and 8 are in the C horizon.

The A and B horizons typically are characterized by a clay loam texture with underlying loam C horizon. Clay percent in the control section ranges between 24 and 32.

Nicollet is somewhat poorly drained, has moderate permeability, and occurs on slightly convex or plane slopes.

Webster

The Webster series was established in Clay County, Iowa in 1916 (Soil Survey Staff, 1974). This soil is classified as a fine-loamy, mixed, mesic, Typic Haplaquoll (Soil Survey Staff, 1975b). Solum thickness is between 61 and 91 cm.

The A horizon is typically 43 cm while the B horizon is 36 cm thick. Depth to free carbonates is the same as solum thickness. The A horizon has hue of 10YR or N, value of 2, and chroma of 0 or 1. B horizon hue is 5Y or 2.5Y, value of 4 or 5, chroma of 1 or 2. C horizon colors are similar to the B horizon. Mottles with hue of 2.5Y and 5Y, value of 3, 4, and 5, chroma of 1, 2, and 3 are common throughout the B and C horizon.

Texture of the A horizon is typically light clay loam while the B horizon texture ranges from light to medium clay loam. Clay percent in the 25 to 102 cm control section ranges from 28 to 35.

Webster is poorly drained and permeability is moderate to moderately slow. It occurs on nearly level to slightly concave slopes.

Canisteo

The Canisteo series was established in Dodge County, Minnesota in 1959 (Soil Survey Staff, 1977). This soil is classified as a fine-loamy, mixed (calcareous), mesic, Typic Haplaquoll (Soil Survey Staff, 1975b). Solum thickness is between 61 and 91 cm.

The A horizon comprises about 51 cm while the B horizon includes about 36 cm of the solum total. Free carbonates occur high in the solum and are in all parts of the fine earth fraction between 25 and 76 cm. A horizon hue includes N and 10YR, value of 2 or 3, and chroma of 0 or 1. B horizon hue includes 2.5Y, 5Y, or 10YR, value of 4 or 5, and chroma of 1 or 2. C horizon hue is 2.5Y or 5Y, value of 5 or 6, and chroma of 2, 3, or 4. Mottles throughout the B and C horizon include hue of 2.5Y, value of 3 or 4, and chroma of 1 or 2.

Texture of the A horizon is typically a clay loam but ranges from loam to silty clay loam to silt loam. Texture of the B horizon is clay loam, loam, silty clay loam, silt loam, or sandy loam. C horizon texture is typically loam but light clay loam and heavy sandy loam are found. Clay percent in the 25 to 102 cm control section averages between 20 and 35.

Canisteo is poorly and very poorly drained, permeability is moderate, and it occurs on concave to slightly convex slopes.

Harps

The Harps series was established in Webster County, Iowa in 1968 (Soil Survey Staff, 1975a). This soil is classified as a fine-loamy, mixed, mesic, Typic Calciaquoll (Soil Survey Staff, 1975b). Solum thickness typically is 107 cm.

The A horizon is typically 41 cm while the B horizon is typically 66 cm thick. Free carbonates are at the soil surface with calcium carbonate content as high as 45% in the 15 to 38 cm depth.

The A horizon has hues of 10YR and N, value of 2 or 3, and chroma of 1. The B horizon hue is 2.5Y or 5Y, value is 5 or 6, and chroma is 1 or 2. Mottles with hue of 10YR and 2.5Y, value of 4 or 5, and chroma of 4 through 8 are throughout the B and C horizons.

Texture of the A horizon is loam or light clay loam while texture of the B horizon is loam, light clay loam, or sandy clay loam. The C horizon is typically loam in texture. The B horizon contains 18 to 30 percent clay.

Harps is poorly drained and permeability is moderate. It occurs on narrow rims or shorelines of depressions.

Okoboji

The Okoboji series was established in Polk County, Iowa in 1958 (Soil Survey Staff, 1976c). It is classified as a fine, montmorillonitic, mesic, Cumulic Haplaquoll (Soil Survey Staff, 1975b). Solum thickness ranges from 102 to 152 cm.

The A horizon is typically 81 cm but ranges from 61 to 91 cm in thickness. The B horizon is typically 61 cm thick. Free carbonates are at depths ranging from 51 to 127 cm.

The A horizon has hues of 10YR or N, value of 2, and chroma of 0 or 1. The B horizon has hue of 10YR, N, and 5Y, value of 3, or 4, chroma of

0 or 1. The C horizon hue is 5Y, value is 4, and chroma is 1. Mottles with hues of 5Y and 2.5Y, value of 4 or 5, chroma of 2, 3, or 4 are in the lower A, B, and C horizons.

Texture of the A horizon is typically silty clay loam, silt loam, or mucky silt loam. The B horizon texture is typically silty clay loam. The C horizon texture is usually silty clay loam to loam. Clay percent in the 25 to 102 cm control section averages between 35 and 40.

Okoboji is very poorly drained and permeability is moderately slow. It occurs in depressions.

PART I. USE OF REGRESSION MODELS TO ESTIMATE WATER TABLE DEPTH AND DURATION

INTRODUCTION

Several soil series comprising the Clarion toposequence have periodic high water tables. Use of these prime soils for either agriculture or urban use is largely based on being able to predict water table depths. Thus, an understanding of those variables related to water table fluctuations is an important tool for making wise land use decisions.

Nelson et al. (1973) used multiple linear regression models to correlate water table fluctuations in soils on the Coastal Plain in North Carolina. Their meteorological variables of cumulative rainfall, antecedent rainfall, and relative humidity in conjunction with time explained water table fluctuations in 42 of 48 sites. Thus, it appeared that these techniques can be used to study water table fluctuations among and between members of the Clarion toposequence. Multiple linear or curvilinear regression models can be developed to predict depth and duration of water tables at any position along a Clarion toposequence traverse.

Specific objectives in this part of the study are:

1. To select one representative undrained and one artificially drained traverse of the Clarion toposequence,
2. To monitor water table fluctuations at soil site locations along each traverse,
3. To select meterological variables related to water table fluctuations,
4. To develop and interpret water table prediction models over time for individual members of the Clarion toposequence for

both undrained and drained conditions,

5. To develop and interpret two overall water table prediction models over time, one for a drained and one for an undrained traverse,
6. To use the prediction models (along with long-term meterological records) to predict the average and range of depth and duration of water tables among and between members of either the drained or undrained Clarion toposequence,
7. To compare predicted and actual water table depths and durations for both drained and undrained traverses, and
8. To compare climatic data during the study with the long-term climatic data in order to determine how long water table measurements should be taken.

MATERIALS AND METHODS

Selection and Description of Study Areas

Field reconnaissance was conducted in Story County, Iowa to investigate the landscape relationships of soils considered to be representative of the Clarion toposequence. Several sites were examined in detail to locate two representative traverses. One traverse was selected to represent a Clarion toposequence with undrained conditions while the other traverse was selected to represent an artificial or tile drained system. Figure 4 shows the location of these traverses.

In order to determine watershed boundaries, a topographic map (30.5 cm or 100 ft grid) of each area was constructed. Soil survey maps of these water sheds were also made. Topographic delineations (30.1 cm or 1 ft contour) and soil mapping unit boundaries were drawn on aerial photos.

A Giddings hydraulic soil coring machine was used to extract 3.8 x 300 cm soil cores within each traverse. Six soil cores from each traverse or a total of 12 soil cores were taken. Perforated 3.8 x 400 cm plastic PVC-160 pipes were stoppered on the bottom end and inserted into each core hole. Approximately 90 cm of pipe extended above the ground surface. In order to prevent tube contamination, each pipe was capped with a rubber stopper.

The water table level was recorded at each water table observation well approximately weekly from November 1, 1977, through October 31, 1978, biweekly from November 1, 1978, through October 31, 1979, and monthly

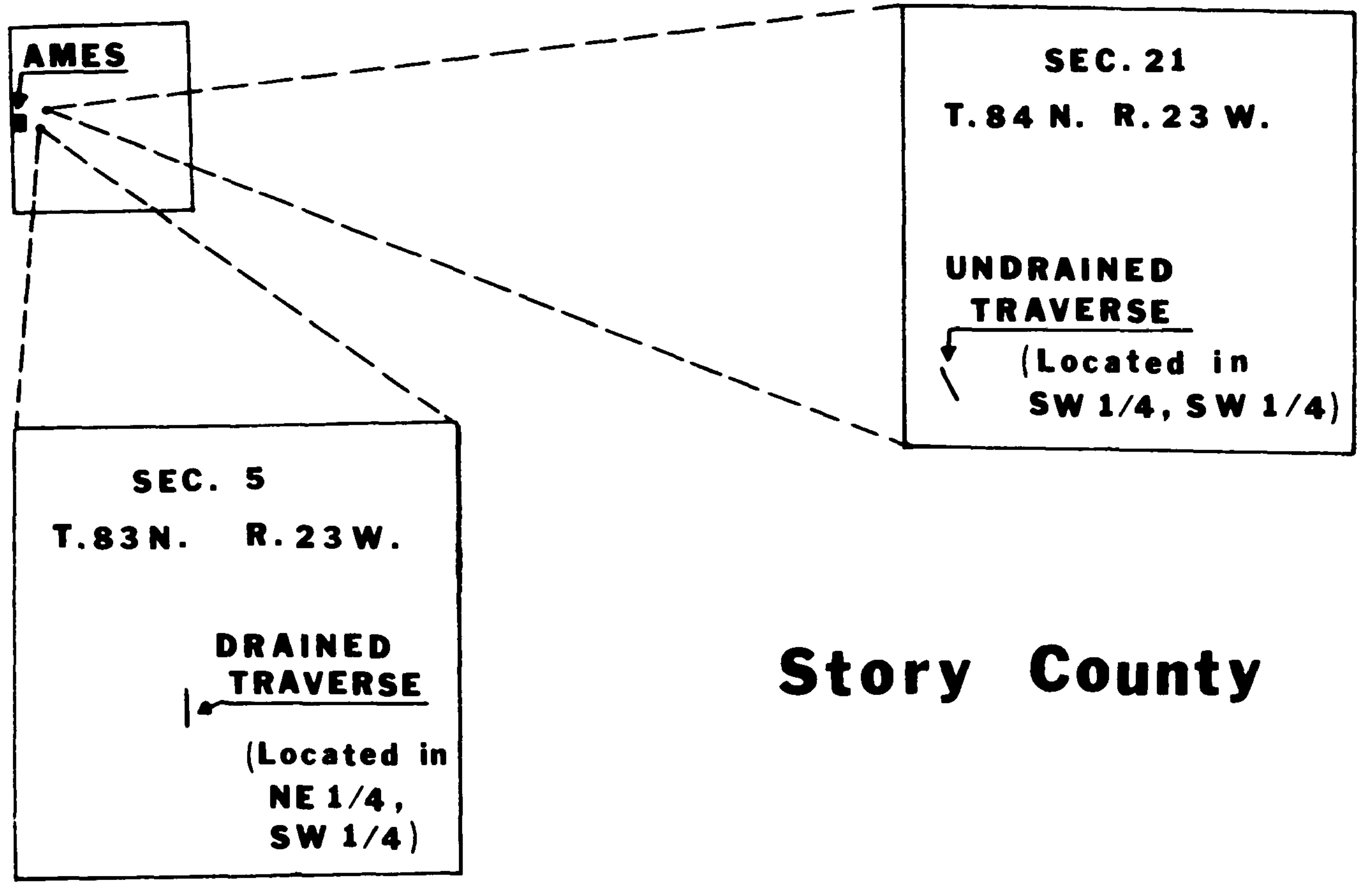

Figure 4. Locations and legal descriptions of study areas in relation to Ames and Story County, Iowa

from November 1, 1979 through October 31, 1980. A battery-powered drop line meter[1] was used to measure the depth to the surface of the water table.

Regression Equation Variables for Individual Sites

Antecedent precipitation

Antecedent precipitation (ANP) was defined as the amount of precipitation received at the site during the 30-day period prior to the date of water table measurement. These values, recorded in centimeters, are given in Appendix A.

Cumulative precipitation

Cumulative precipitation (CP) was defined as the amount of precipitation received at the site between water table measurements. These values, in centimeters, are recorded in Appendix A.

Both antecedent and cumulative precipiation values were calculated from unpublished weather records of the Ames Pollution Control Center, Ames, Iowa. This weather station was selected because traverse number 1 (tile drained) is located 4.1 km northeast while traverse number 2, (undrained) is located 8.2 km northeast of the Ames Pollution Control Center. Monthly mean, minimum, and maximum precipitation for the 36-month period of the study are also given in Table 2.

Evapotranspiration

Values used to estimate the amount of evapotranspiration (EV) were obtained from data that were calculated by a computer program for

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[1] Soiltest Engineering Test Equipment Model DR 760 A, Soiltest, Inc., 2205 Lee Street, Evanston, Illinois.

Table 2. Monthly precipitation totals for each year and the mean, minimum, and maximum monthly totals during the 36-month study period (data from rain gauge at the Ames Pollution Control Center)

	Total monthly precipitation (cm) for the following years				Precipitation (cm) in the three years		
Month	1977	1978	1979	1980	Mean	Minimum	Maximum
January	--	1.6	4.0	2.8	2.8	1.6	4.0
February	--	2.6	0.8	1.1	1.5	0.8	2.6
March	--	1.7	10.1	1.4	4.4	1.4	10.1
April	--	12.2	8.5	3.0	7.9	3.0	12.2
May	--	6.5	6.7	7.8	7.0	6.5	7.8
June	--	10.7	13.0	11.5	11.7	10.7	13.0
July	--	15.4	10.8	4.9	10.4	4.9	15.4
August	--	13.8	29.2	10.2	17.7	10.2	29.2
September	--	12.6	6.7	4.9	8.1	4.9	12.6
October	--	2.0	11.6	3.3	5.6	3.3	11.6
November	1.4	6.2	5.8	--	4.5	1.4	6.2
December	2.2	2.1	1.9	--	2.1	1.9	2.0

estimating soil moisture under corn (Dr. R. H. Shaw, Agronomy Department, Iowa State University, unpublished data, 1981). Shaw (1963) presented the procedures used to determine evaporation for the April - June, June - August, and August - November periods. During the winter period, Shaw used 0.25 cm per day or less; this was an average and included evaporation only.

Evapotranspiration (EV) values that are listed in Appendix A were calculated from data collected on a Nicollet soil series site located at the Agronomy and Agriculture Engineering Research Center west of Ames on U.S. Highway 30. Evapotranspiration (EV) in cm that occurred from on U.S. Highway 30. Evapotranspiration (EV) in cm that occurred from 1 to 30 days prior to the date of the water table (WT) measurements was totaled and recorded. Only those evapotranspiration (EV) values for November 1, 1977, through October 31, 1980, were recorded in Appendix A. Evapotranspiration (EV) values for winter months were recorded as "0" in Appendix A.

Net percolating water

The amount of water percolating below the 152 cm depth was defined as net percolating water (BPW). These values were calculated by the same computer program referred to for evapotranspiration (EV). Total amount of water percolating below 152 cm between days of water table (WT) measurements for November 1, 1977, through October 31, 1980, is shown for the day of water table measurement. These net water (BPW) values are reported in cm and listed in Appendix A.

Time

The date (TDN) when each water table measurement was taken was listed on the data cards as month (Jan. = 1 to Dec. = 12), day of the month, and year (last two digits); these dates, in the months and years shown in Table 2, are listed in Appendix A. For regression analysis, the time variable (TDN) was obtained by transforming each date of measurement within years from Jan. 1 - 1 to Dec. 30 = 365. These transformations are also listed in Appendix A. Data from all years were combined in the regression analysis.

Days between water table readings

Water table levels were not read on the same day of the week or month throughout the duration of the study. To account for this inconsistency, the variable (DB), or number of days between water table measurements, was included.

Water table

The depth to the water table was the dependent variable in this part of the study. Depths to the surface of the water table (WT) from the soil surface were measured initially. Later, these depths were transformed to distances above a base line and are listed in Appendix A. This was done so that data from all soils in the traverse, with a common base line for WT measurement, could be readily combined in the regression analysis.

To transform these water table (WT) measurements the following elevations above sea level were used. Elevations at the soil surface for soils in the tile drained traverse were as follows: Clarion = 309.7 m, Nicollet = 308.5 m, Webster = 307.7 m, Canisteo = 307.4 m, Harps = 307.1 m, and Okoboji = 306.8 m. Base line for the drained traverse was fixed at 302.0 m. Elevations at the soil surface for soils in the undrained traverse were as follows: Clarion = 297.1 m, Nicollet = 296.4 m, Webster = 295.8 m, Canisteo = 295.7 m, Harps = 295.5 m, and Okobjoi = 294.8 m. Base line for the undrained traverse was fixed at 291.0 m.

The base line elevation was selected to be below the lowest water table measurement from the soil surface. All water table measurements were transformed to be so many meters above these base lines. For example, in TRV1, SS1, on December 12, 1977, the depth from the surface to the water table was 2.6 m. Therefore, the transformed water table level = 309.7 m minus 2.6 m minus 302.0 m = 5.1 m above the base line (Appendix A).

Traverse variables

In addition to those variables already mentioned for the individual sites, two additional independent variables were included to characterize the positions of the individual sites in the complete traverse. They were distance from edge of watershed to the individual site (SD) and percent slope at each individual site (SL). These can be determined from Appendix B.

Statistical Analysis

The study of water table fluctuations involves variables that occur naturally and as such they can not be controlled. Thus, these variables must be considered simultaneously. In order to study the effect of one variable or a group of variables on water table levels, multiple regression techniques were employed.

Multiple regression model

The procedure outlined by Henao (1976) and modified by Salih (1980) to include the cubic function of a variable and its higher-order interactions with other variables was used to provide estimates of the effects of selected variables[1] on water table levels. All computations were

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[1]The term "variable" will refer to a factor under study whose effect in the regression model and analysis may be a function of one or more variates or terms (X_i). Variate will refer to a single term included in the multiple regression model and analysis.

carried out with respect to the model:

$$Y_i = B_0 + B_1X_{1i} + B_2X_{2i} + \ldots + B_pX_{pi} + \varepsilon_i \quad ,$$

where Y_i is the dependent variate, X_{1i}, X_{2i}, ... X_{pi} are explanatory factors assumed to be independent, ε_i is the error term since the independent variates do not explain Y_i completely, and the parameters B_0, B_1, B_2, ... B_p are the population regression coefficients. The usual assumptions in regression analyses were made except that it was recognized that the Xs in these data were intercorrelated to a varying degree and that some of the Xs had errors of estimation or measurement. Pena-Olvera (1979) studied intercorrelations among "independent" soil variables and discussed the effects of intercorrelation on the results of multiple regression analysis.

Selection of final models was by stepwise, backward elimination of nonsignificant variates using the PROC GLM procedure (SAS, 1979). The criteria for retaining variates in the model were: (1) if the simple correlation between two variables was $> \pm 0.60$, alternate models including each variable were run; the variable of a pair of correlated variables retained in the final model was the one in the alternate model that had the higher R^2 and (2) from the t-tests of the partial regression coefficients of the variates, the variates retained in the final model were those significant at $\alpha = 0.05$ except that (a) a linear variate was retained regardless of its significance if its squared variate or one of its interaction variates was significant, (b) the squared and cubic variate of time of year (TDN) was retained regardless of significance if one of its interaction variates was significant at $\alpha = 0.05$, and (c) a lower-order interaction of time of year (TDN) and another variable was retained regardless of its significance if the higher-order interaction was significant at $\alpha = 0.05$.

Regression equation starting point in time

Inspection of preliminary water table curves indicated that the depth to and duration of water table data followed a cubic function. Thus, both minimum and maximum water table inflections that occur within a 12-month period must be well defined. Generally, since a yearly maximum water table inflection occurred during a time from February to May and a yearly minimum water table inflection occurred from April to mid June, a starting time of January 1 in the calendar year was selected. The dates when the water tables were measured then were coded Jan. 1 = 1 to Dec. 30 (Dec. 29 in 1980) = 365 so that time of measurement could be expressed as a continuous function.

Water table measurements from all years were combined in the regression analysis so that depth to water table (transformed to height above a base line) could be expressed as a continuous function of time during the year. Other variables were added to the regression model to explain differences in the magnitude and duration of the maximum and minimum inflections in the 3 years of the study.

Interpretation of the regression models

Although the primary objective of this part of the study was to develop multiple regression equations to predict water table depth and duration during the year (over time) at various levels of other variables affecting this relationship, the effects of all variables on water table depth are also of interest. The initial regression models for water table level (WT) included the cubic function of time (TDN), quadratic functions of the other variables, all possible linear*linear interactions between variables, and the complex interactions between the quadratic and cubic functions of TDN and linear functions of all other variables. The effects of the variables on water table in the final models varied from simple to complex relationships involving a few to many interaction variates.

One way to study the effect of a variable on the dependent variable (WT) is to compute the partial derivative of WT with respect to the variable. From the partial derivative, the slope (change in WT per unit change of the variable) of the response of WT to the variable can be determined at any level of the variable and interacting variables. If the variable has a quadratic effect on WT, the level of the variable associated with the maximum or minimum WT can be determined from the partial derivative. If the variable has a cubic effect on WT, the levels associated with both maximum and minimum WT can be determined. If interactions are present, the effect of the other variable or variables on the relationship between the first variable and WT also can be determined from the partial derivative.

The use of and the mathematics of partial derivatives to describe the effects of independent variables on the dependent variable were described in detail by Salih (1980, p. 50-61). His regression models included quadratic functions of variables, a cubic function of one variable, linear*linear (L*L) interactions between all variables, and the quadratic*linear (Q*L) and cubic*linear (C*L) interactions between the variable with the cubic function and all other variables. He discussed the partial derivatives for the following cases: (1) the linear and quadratic functions of a variable and its L*L, L*Q, and L*C interactions with the variable having the cubic function and (2) the cubic function of a variable and its L*L, Q*L, and C*L interactions with another variable.

The effect of the cubic function of a variable on the dependent variable is more complex because L*L, Q*L, and C*L interactions with more than one variable may be involved. Salih (1980, p. 136-137) reported that the partial derivative with respect to the cubic function of a variable and its interactions with other variables could be simplified by setting all other variables, except the one with the cubic function and the one to be studied, at constant values.

Another method that Salih (1980, p. 137-143) used to illustrate the effect of the cubic function of a variable and its interactions with a second variable on the dependent variable was to simplify the regression equation by substituting constant values for all other variables in the equation and collecting terms. The simplified regression equation at fixed levels of the other variables thus contained the cubic function on one variable, the linear or quadratic function of the interacting variable, and 1 to 3 interactions between the two variables. The simplified regression equation then was used to compute and plot the changes in the dependent variable with changes in the variable with the cubic function and at different levels of the second variable. In three examples, he illustrated the effects of the cubic effect of the variable on the dependent variable as successively higher-order interactions with another variable were included.

The mathematics and use of partial derivatives and other methods to describe variable effects on the dependent variable will not be detailed in this dissertation. The reader is referred to the discussion in Salih (1980) for these details.

RESULTS AND DISCUSSION

The soils and topographic map for the artificially drained study area are shown in Figure 5. This watershed covers an area of about seven hectares. Watershed boundary and soil boundaries between Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji are shown. Topographic lines, which were drawn from a 100-ft grid, and approximate elevation in feet above sea level are also given.

Interpretation of black and white shades on the aerial photo reveals that a correlation between these color tones and soil patterns occurred. This soils map agrees with Gwynne (1941) who observed that lighter colored areas and areas of higher elevation contained soils characterized as having less organic matter and less water. Darker counterparts correlated with adjacent depressional areas which have soils containing more organic matter and more water. Generally, Figure 5 shows that Clarion occurred on the highest and lightest colored portions of the landscape. As elevation decreased and color tone became darker, soils contained more organic matter and became poorer drained.

Figure 5 shows that the distance between Clarion and Okoboji sites was about 168 m and the corresponding elevations decreased approximately 2.4 m. One tile drain, shown as a lighter 1 mm streak which exits from the watershed south from the Okoboji soil area, drains the entire watershed.

The soils and topographic map for the undrained study area is shown in Figure 6. This study area is somewhat larger than the artificially

Figure 5. Soil and topography map for artificially drained Clarion toposequence, Traverse number 1

Legal description for Traverse number 1: NE¼, SW¼ of Sec. 5, T. 83N., R. 23W., Story County, Iowa.

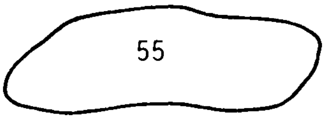
Guide to mapping units:

Map symbol	Mapping unit
6	Okoboji silty clay loam
55	Nicollet loam, 0 to 2% slopes
95	Harps loam, 0 to 2% slopes
107	Webster clay loam, 0 to 2% slopes
507	Canisteo clay loam, 0 to 2% slopes
138B	Clarion loam, 2 to 5% slopes

Guide to conventional signs:

Boundaries

Soil boundary and symbol



Watershed boundary

Topographic boundary and elevation

(in feet above sea level) 1016

Soil series site location ⊕

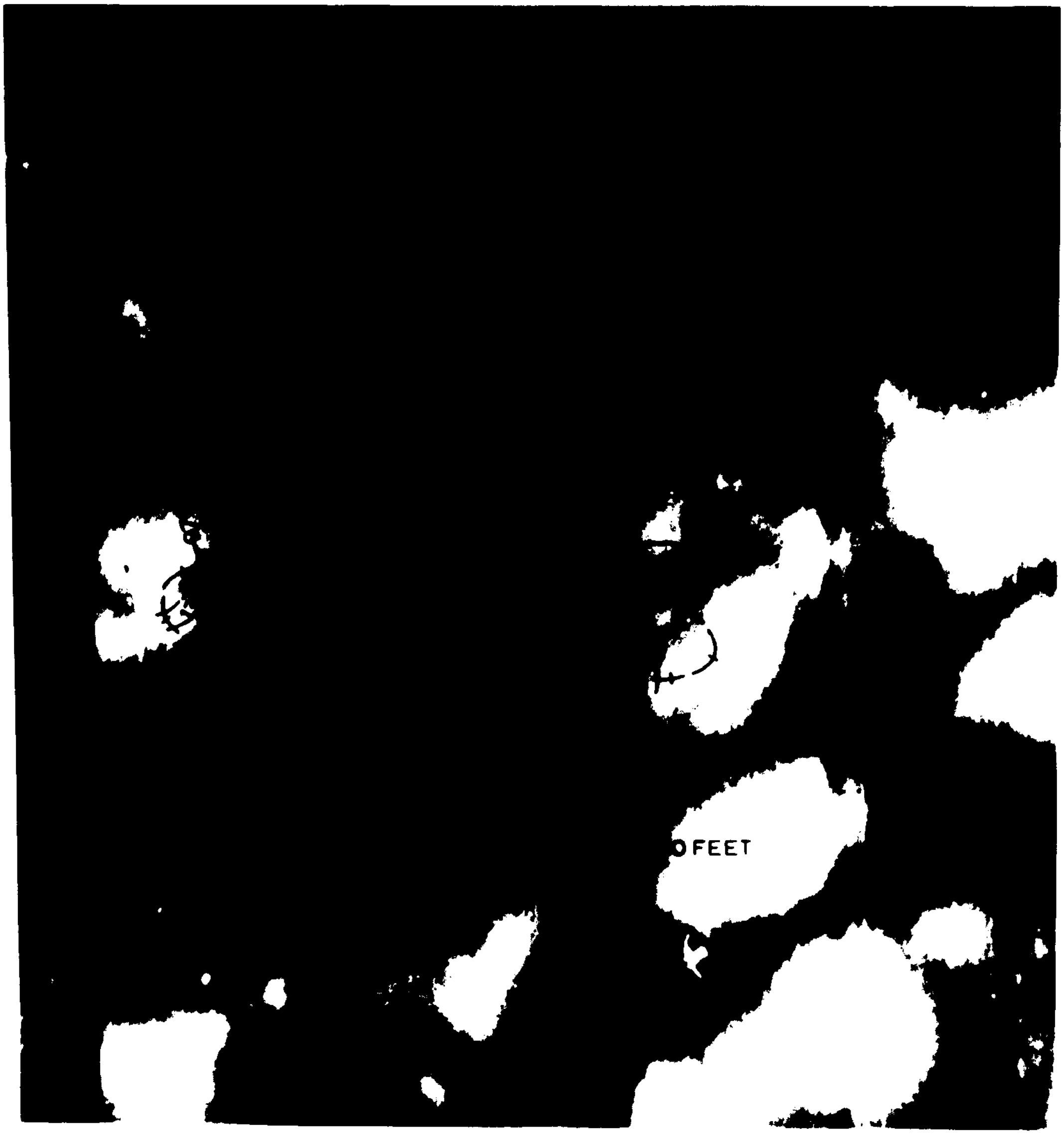

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Figure 6. Soil and topography map for undrained Clarion toposequence, Traverse number 2

Legal description for Traverse number 2: SW¼, SW¼ of Sec. 21, T. 84N., R. 23W., Story County, Iowa.

Guide to mapping units:

Map symbol	Mapping unit
6	Okoboji silty clay loam
55	Nicollet loam, 0 to 2% slopes
95	Harps loam, 0 to 2% slopes
107	Webster clay loam, 0 to 2% slopes
507	Canisteo clay loam, 0 to 2% slopes
138B	Clarion loam, 2 to 5% slopes

Guide to conventional signs:

Boundaries

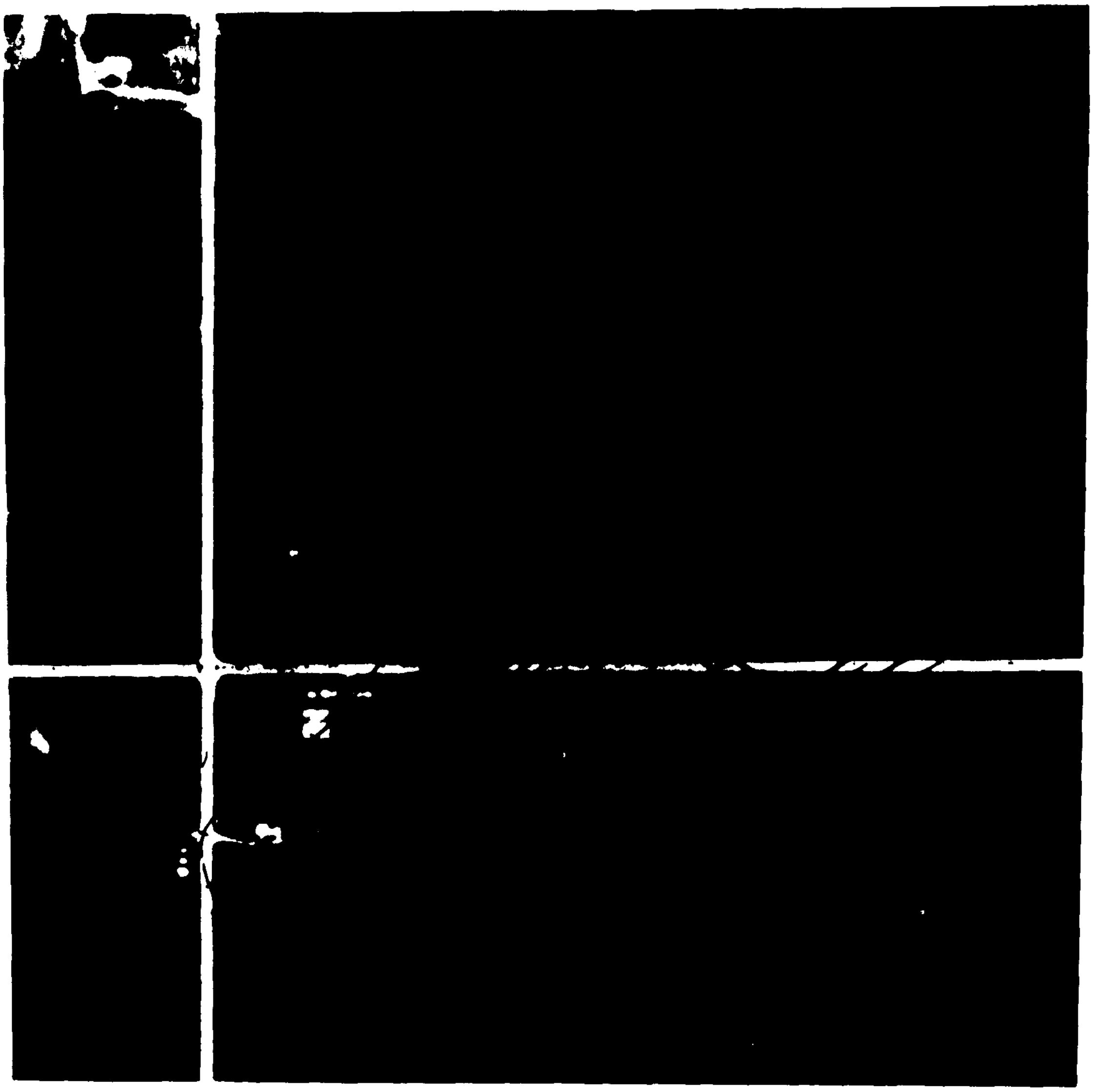
Soil boundary and symbol 55

Watershed boundary

Topographic boundary and elevation

(in feet above sea level) 976

Soil series site location



drained study area in that it covers an area of about 16 hectares. Watershed boundary, soil boundaries, topographic lines, and discussion relative to photo color and soil landscape relationships as presented for the artificially drained study area also apply to this undrained study area. Distance between Clarion and Okoboji as shown in Figure 6 is about 171 m with a corresponding elevation difference of about 2.4 m.

According to Robert Cooper, owner of the undrained study area, this Clarion toposequence is undrained. Although a tile drain was installed during the early 1900s, the system has never worked. This tile came into the SW corner of Sec. 21 from the west but never extended far enough to drain the watershed.

Depth and Duration of Water Table in the Clarion Toposequences

Artificially drained traverse

Depth and duration of water tables in each of the soil series members of the artificially drained Clarion toposequence are shown in Figures 7 through 12. Each figure shows water table fluctuations plotted in tenths of a meter above a base line by time in months. The soil surface and the 1.6 m soil profile depth are shown. Data year number 1 covered a time span from November 1, 1977, through October 31, 1978. This plot of water table fluctuations was developed from water table measurements taken about every 10 days. In data year number 2, which covered a time span from November 1, 1978, through October 31, 1979, water table measurements were taken about every 20 days. The third and final data year covered a time span from November 1, 1979, through

October 31, 1980, and its plot of data was from water table measurements taken about every 34 days. Data for these three data years are presented in Appendix A.

Generally, maximum depth to the surface of the water table in the Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji in this traverse occurred from February through May while minimum depths occurred from May through June. These water table fluctuations reflected seasonal precipitation and plant use. For example, depth to water table was least in the spring and fall, when precipitation was greatest and evapotranspiration was lowest. Similar research by DeWitt (1978) on water table fluctuations in selected soils on the Des Moines Lobe correlated with this pattern of seasonal water table fluctuations.

Maximum and minimum inflections of water table depths occurred in the Clarion (Figure 7). The magnitude between maximum and minimum inflections decreased as percent slope decreased and as distance from watershed edge increased. Lateral movement of water, which tends to cause a build-up and back-up of water in the lower slope positions, may have also occurred.

Water tables became closer to the soil surface as distance from watershed edge increased and percent slope decreased. Figure 13, which is a plot of mean yearly water table depths, shows this relationship. There was a slight rise in water table level at the higher landscape positions.

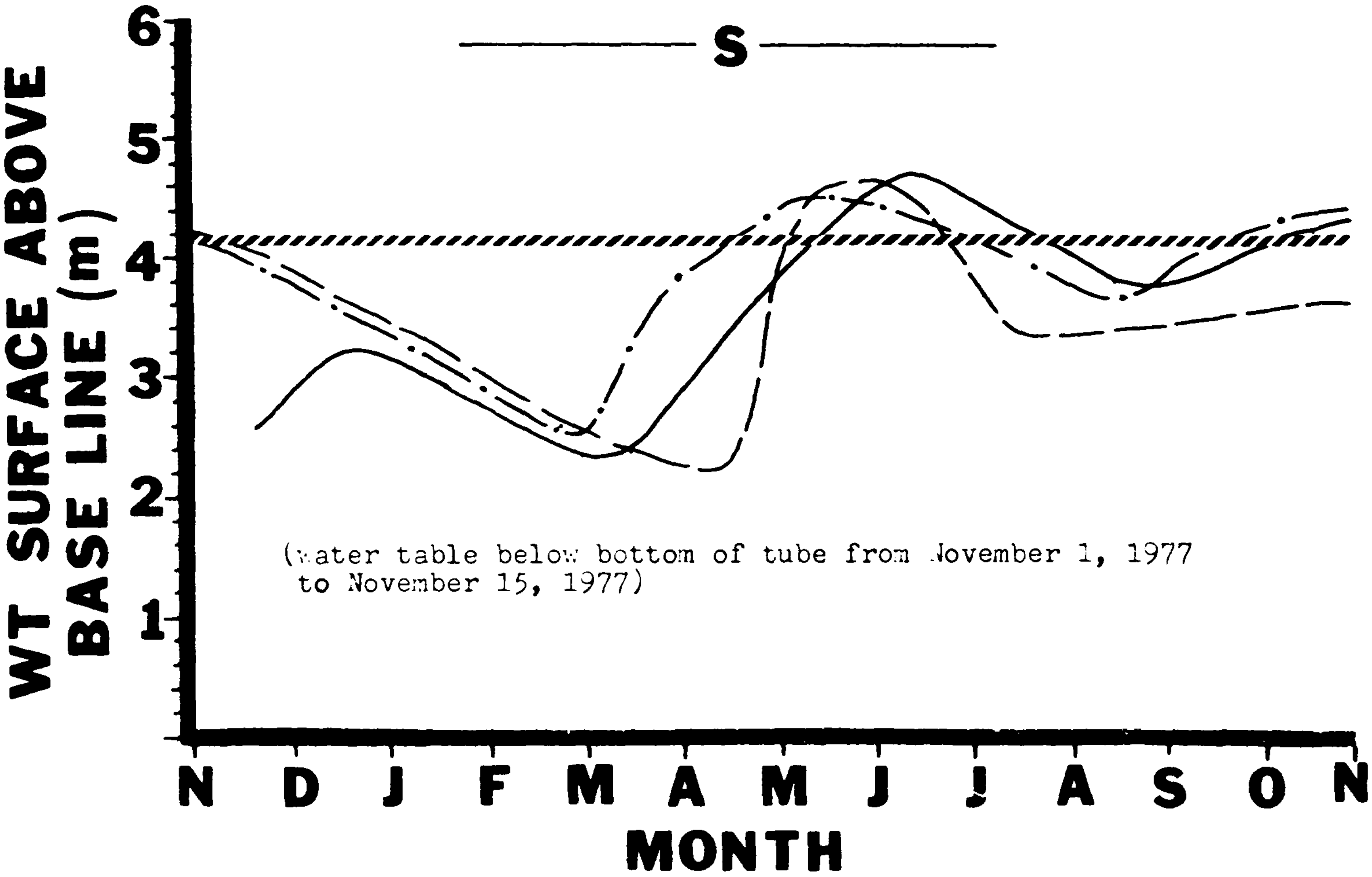


Figure 7. Plot of water table vs. time for Clarion in the artificially drained traverse [(—) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—•—) = November 1, 1979, through October 31, 1980, (////) = 1.6m depth from soil surface, and S = soil surface]

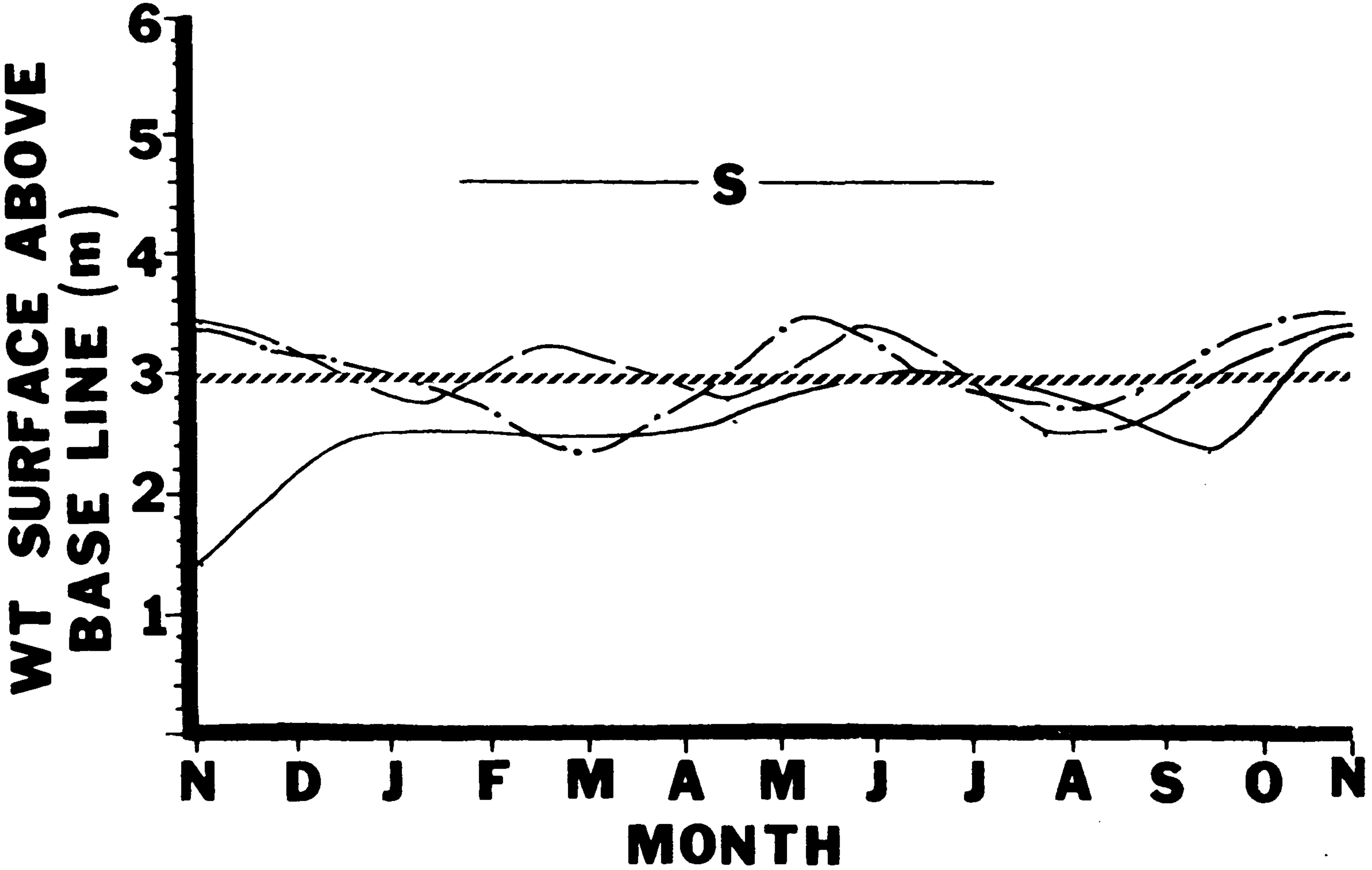


Figure 8. Plot of water table vs. time for Nicollet in the artificially drained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (– · –) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

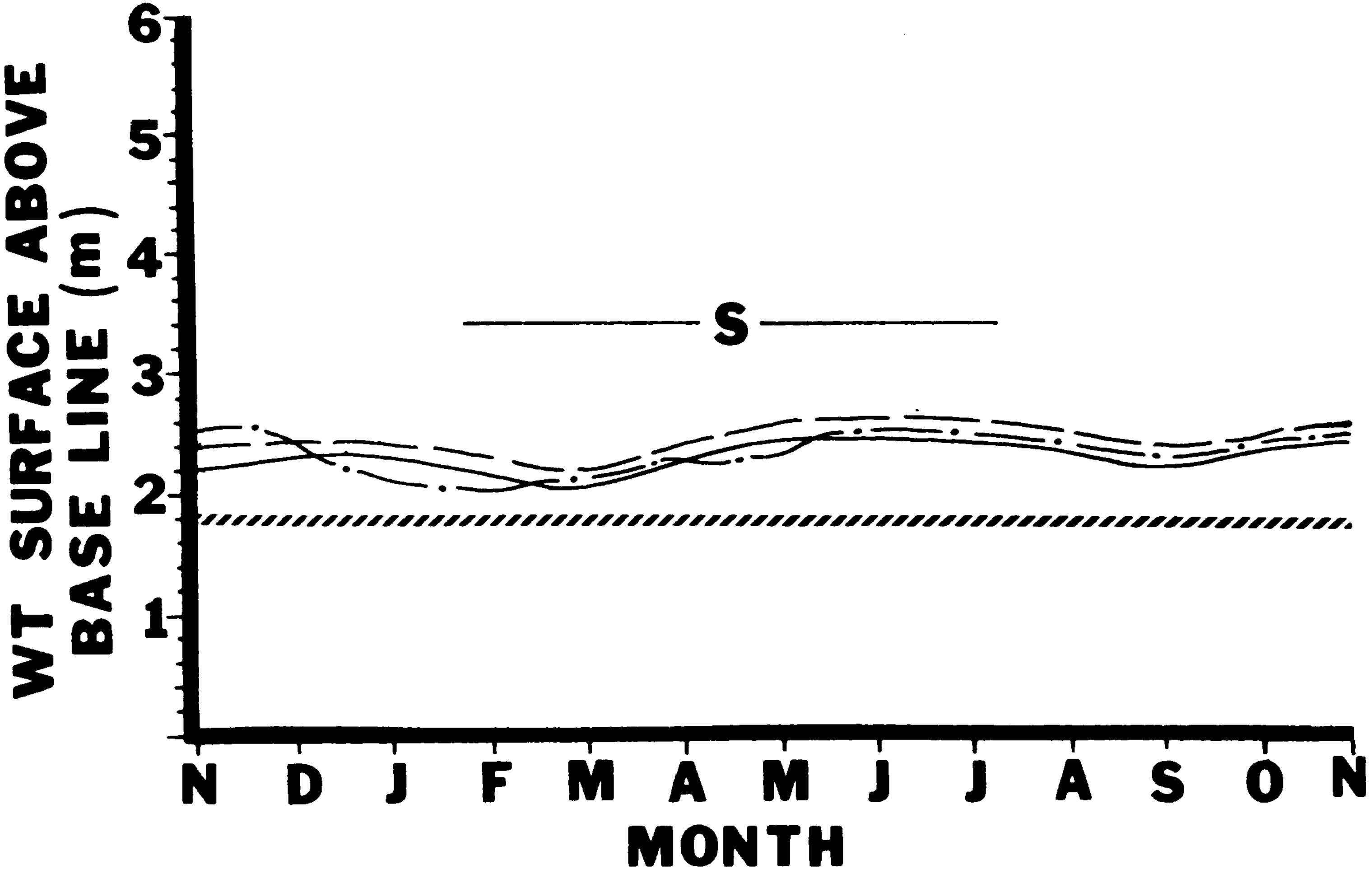


Figure 9. Plot of water table vs. time for Webster in the artificially drained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface, and S = soil surface]

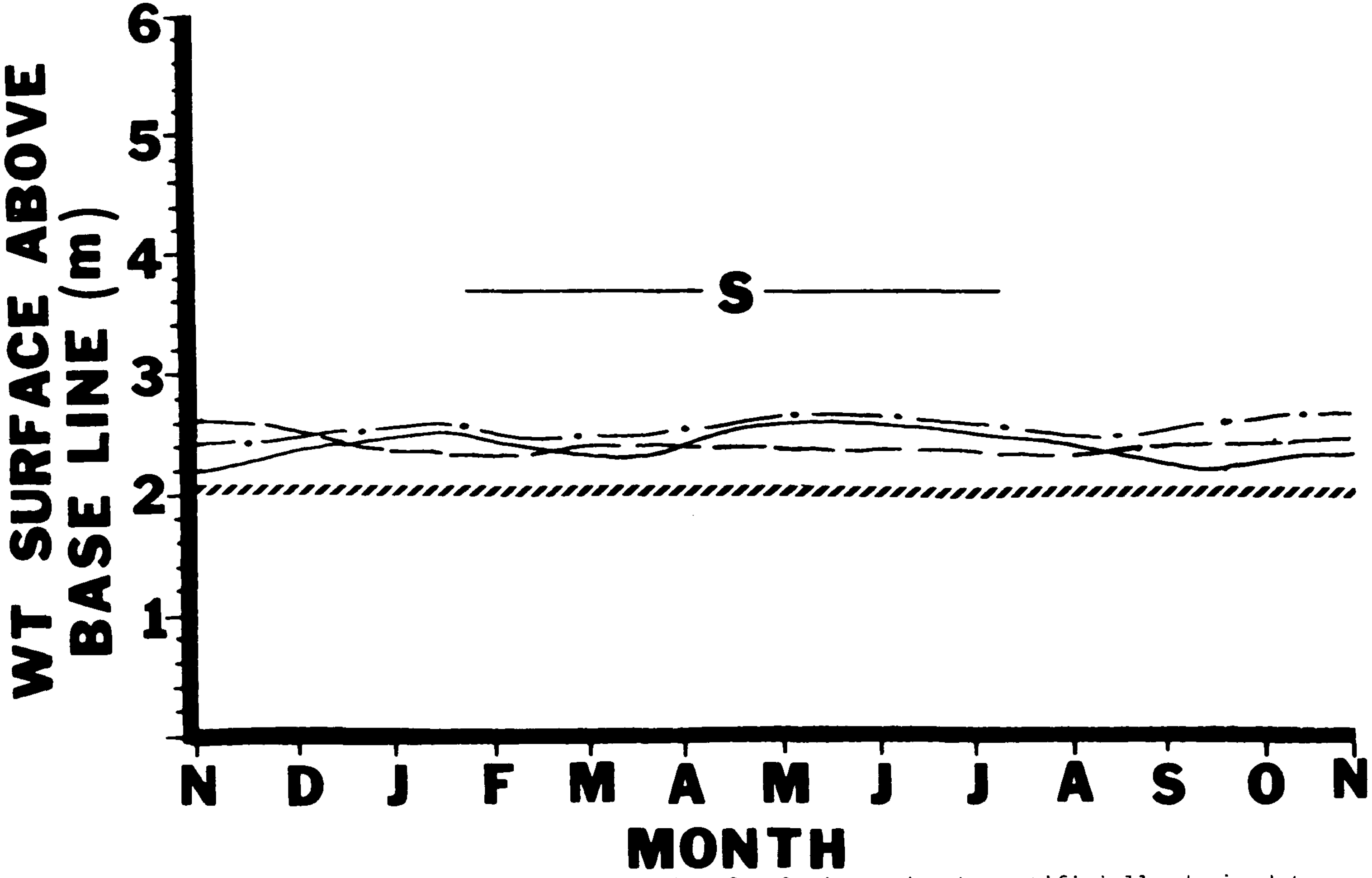


Figure 10. Plot of water table vs. time for Canisteo in the artificially drained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

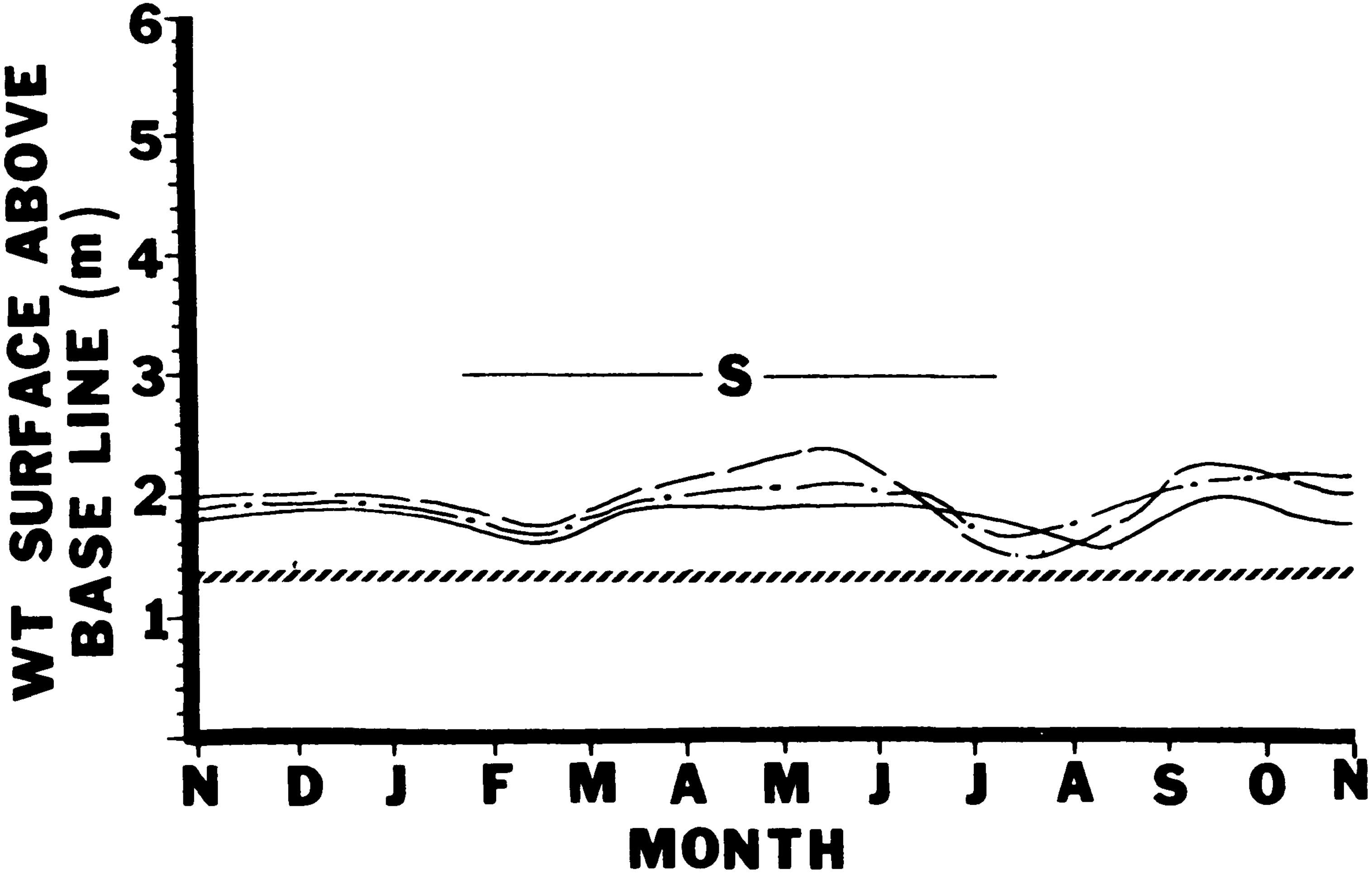


Figure 11. Plot of water table vs. time for Harps in the artificially drained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

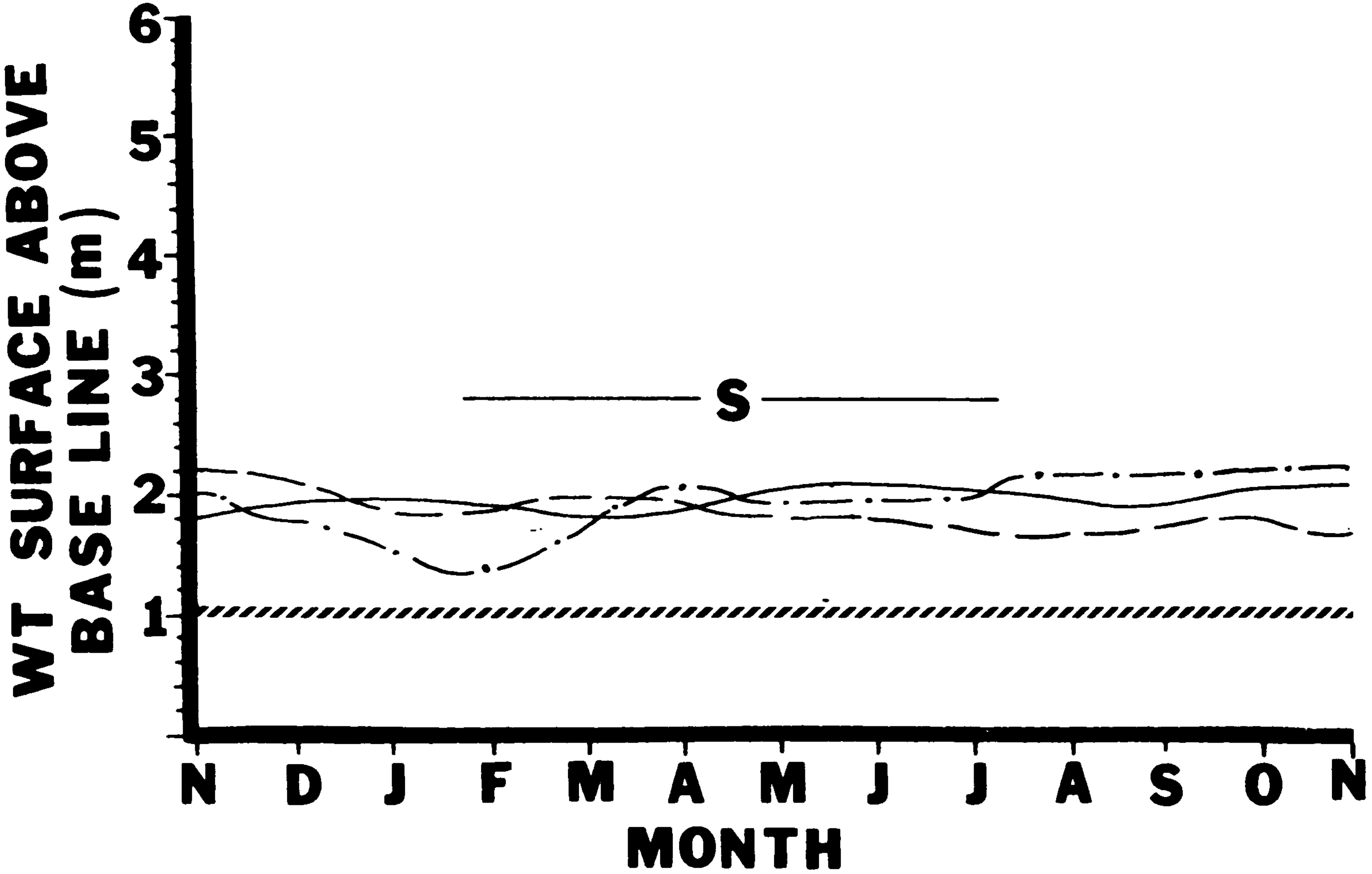


Figure 12. Plot of water table vs. time for Okoboji in the artificially drained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface, and S = soil surface]

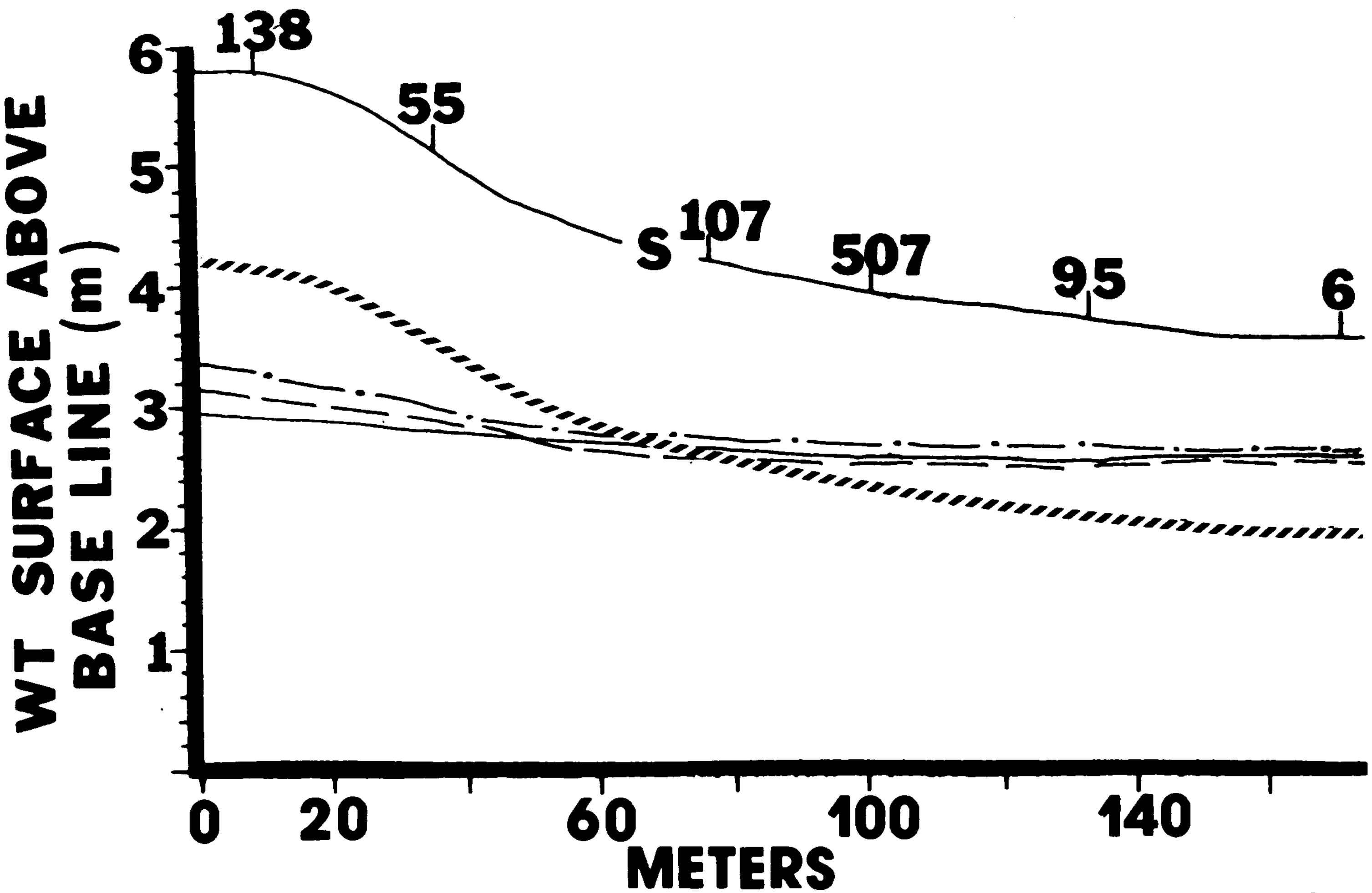


Figure 13. Plot of mean yearly water table depths vs. distance from watershed edge for the artificially drained traverse [where 138 = Clarion, 55 = Nicollet, 107 = Webster, 507 = Canisteo, 95 = Harps, 6 = Okoboji, (——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface and S = soil surface]

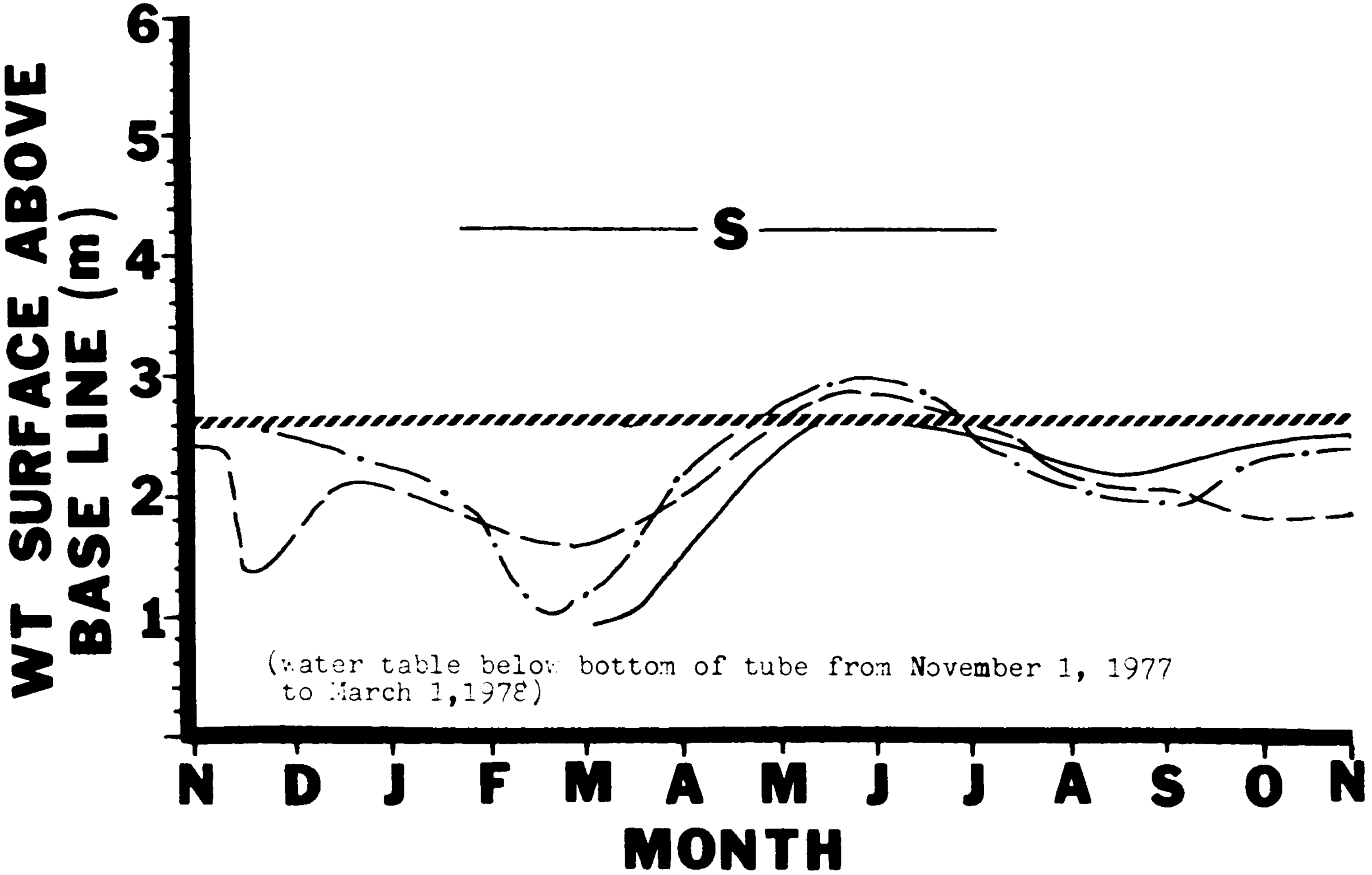


Figure 14. Plot of water table vs. time for Clarion in the undrained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface, and S = soil surface]

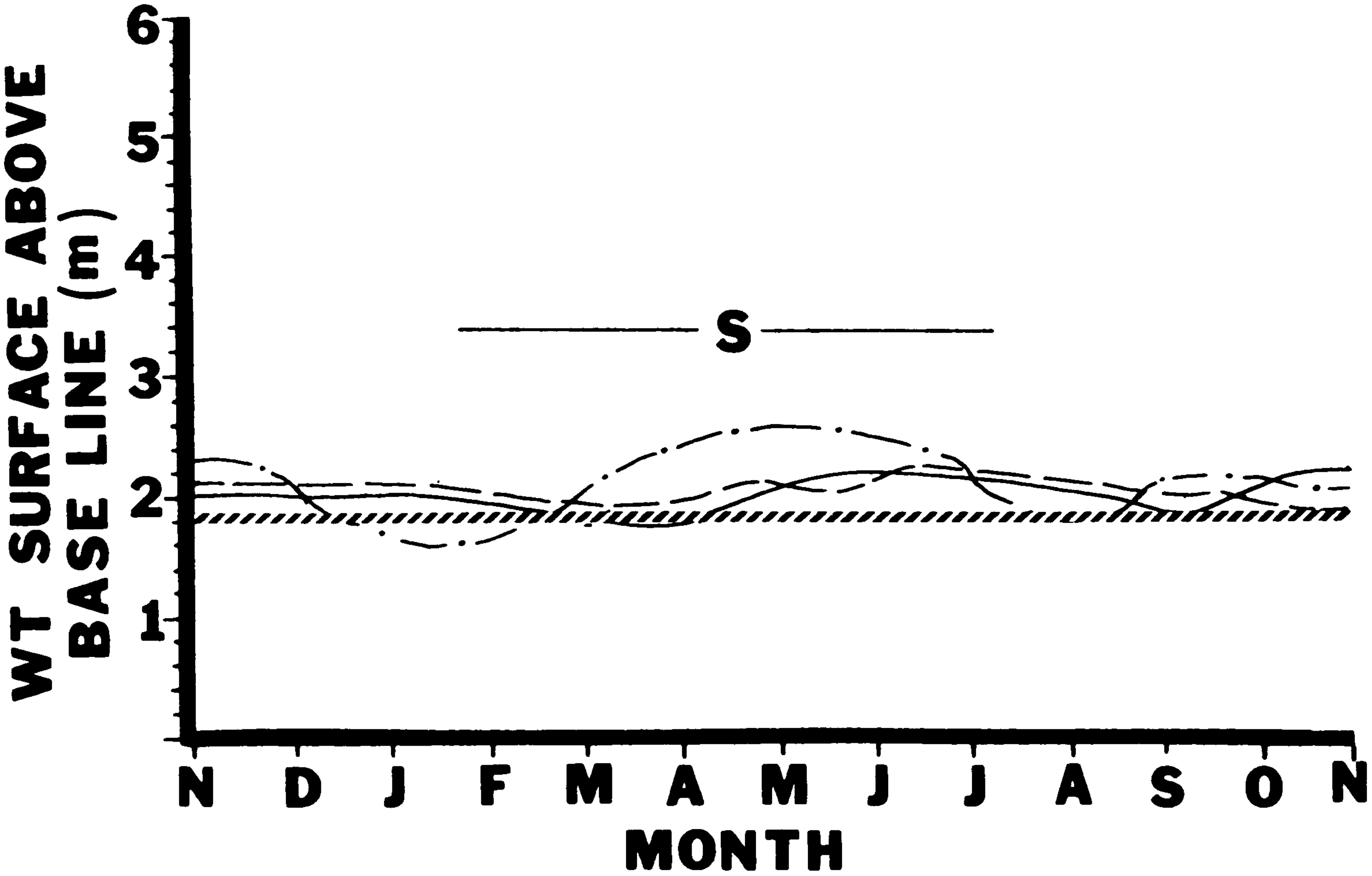


Figure 15. Plot of water table vs. time for Nicollet in the undrained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

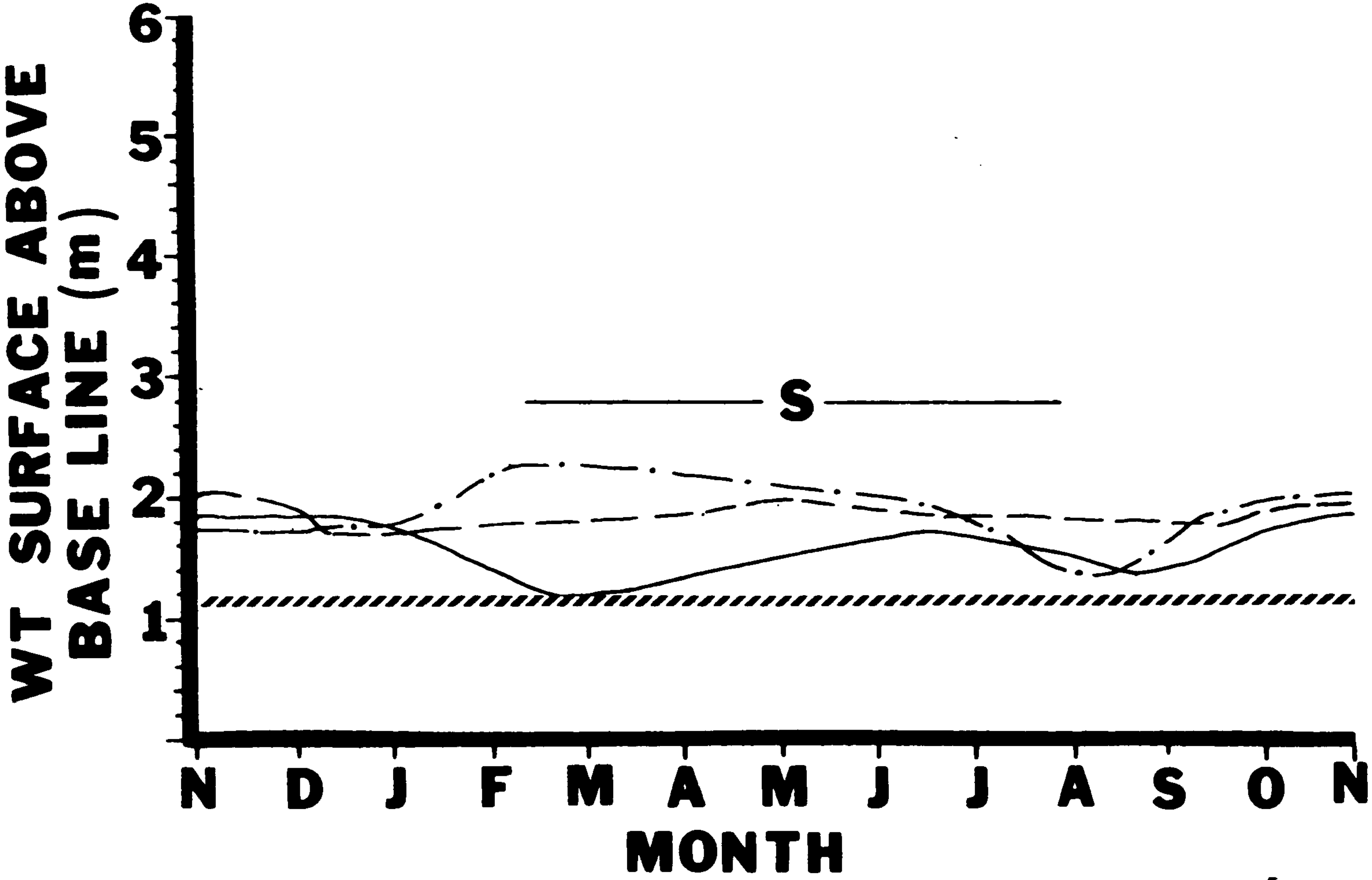


Figure 16. Plot of water table vs. time for Webster in the undrained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

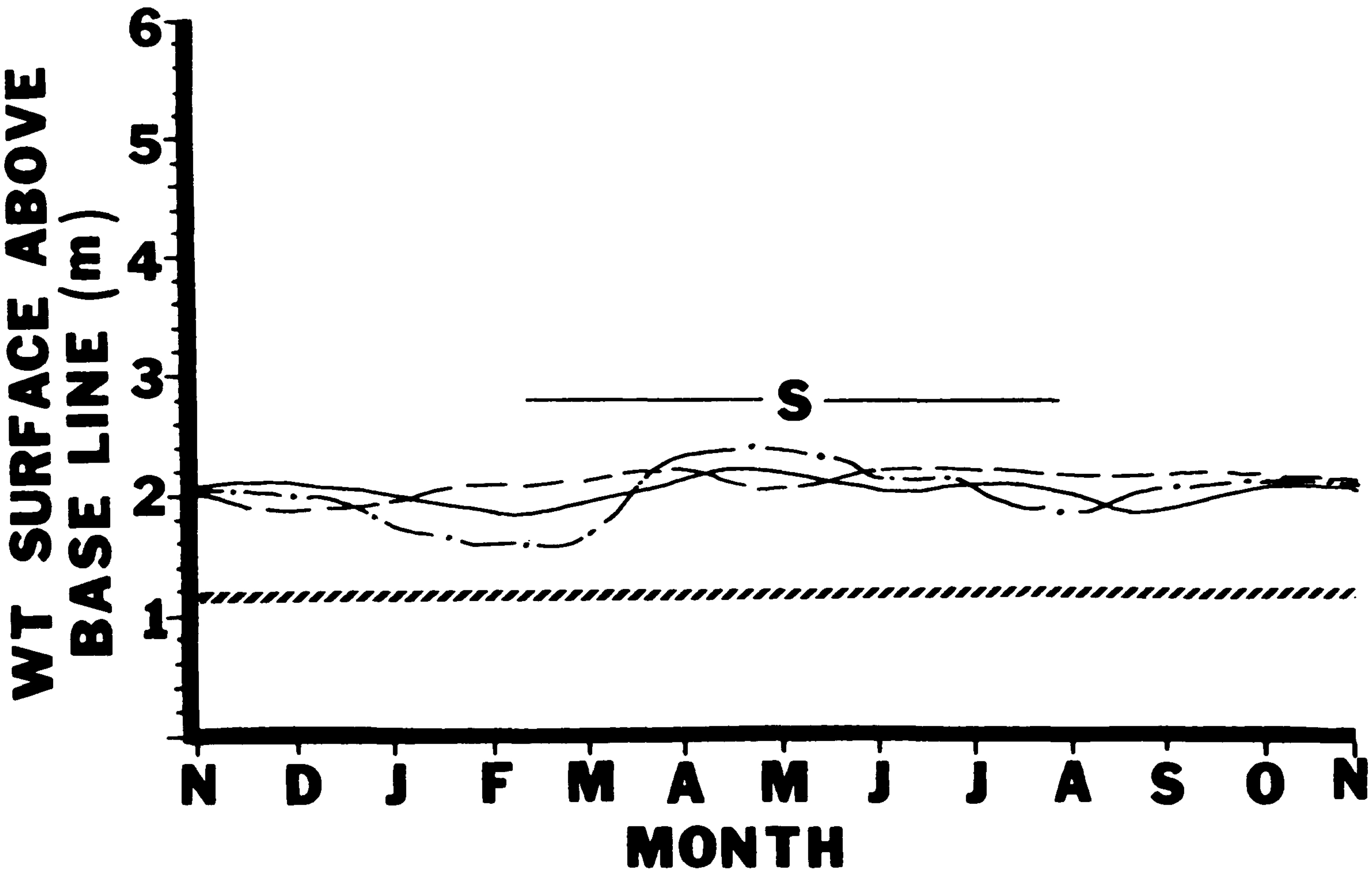


Figure 17. Plot of water table vs. time for Canisteo in the undrained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (////) = 1.6 m depth from soil surface, and S = soil surface]

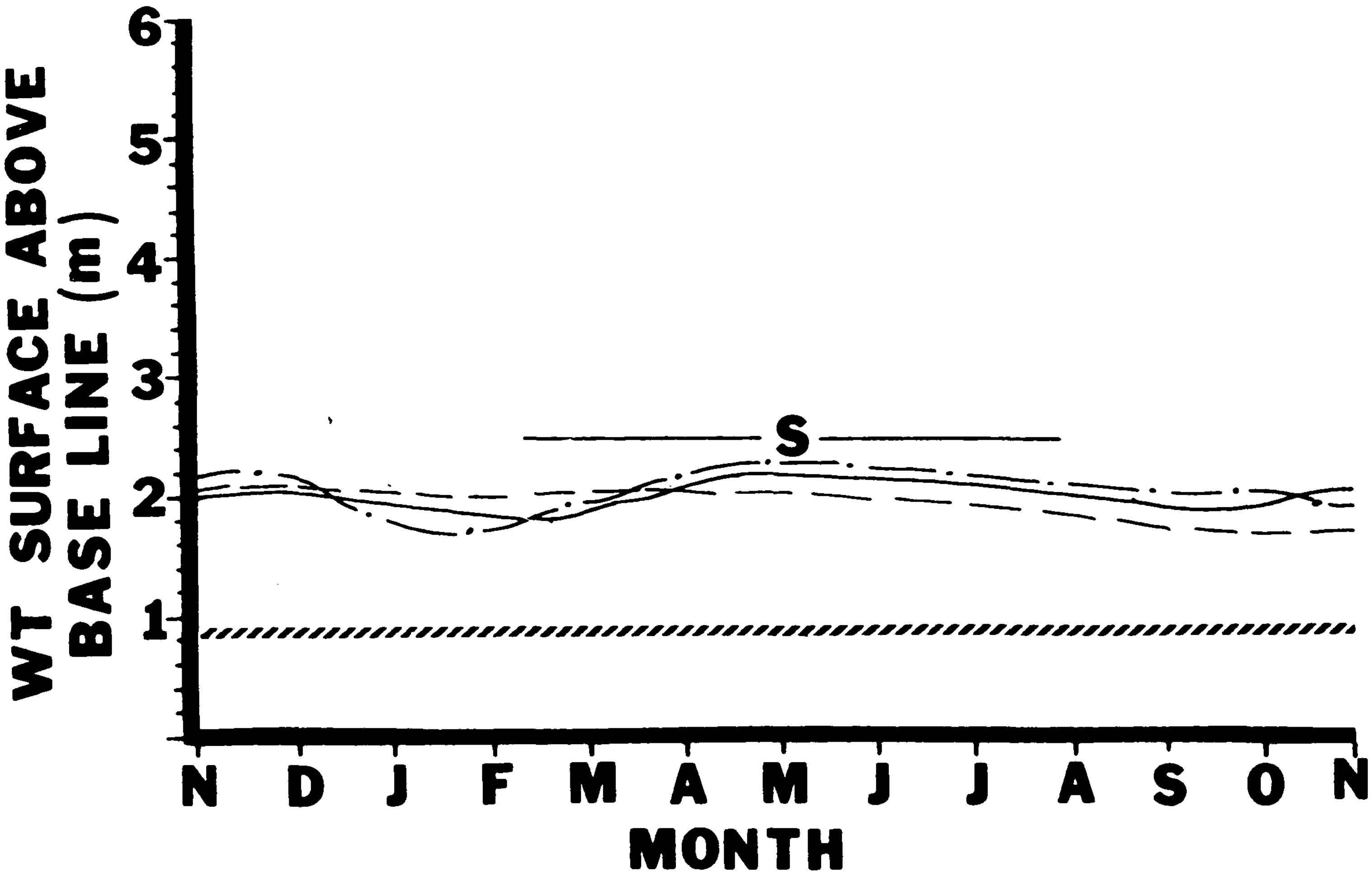


Figure 18. Plot of water table vs. time for Harps in the undrained traverse [(——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface, and S = soil surface]

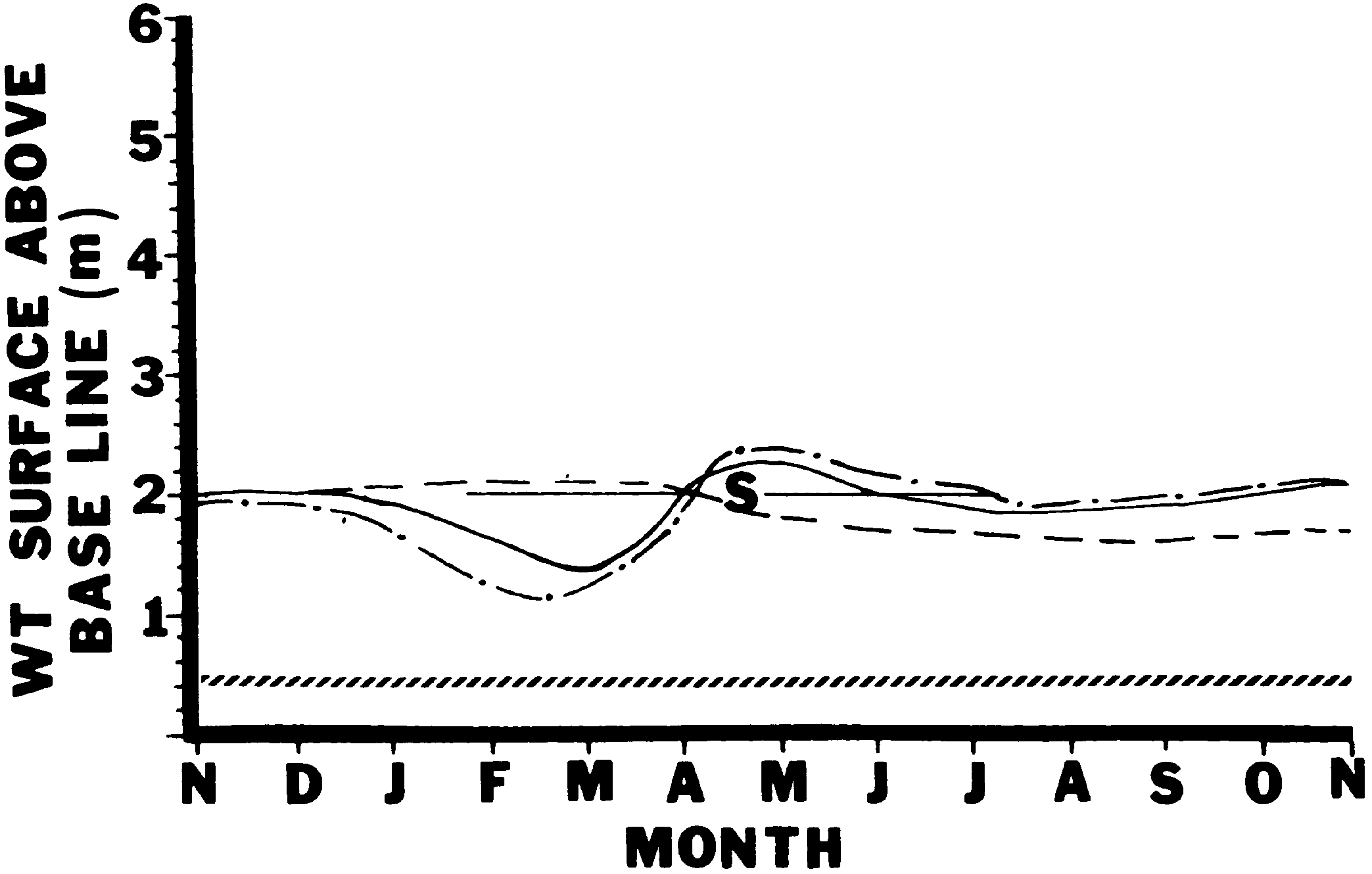


Figure 19. Plot of water table vs. time for Okoboji in the undrained traverse [(—) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface, and S = soil surface]

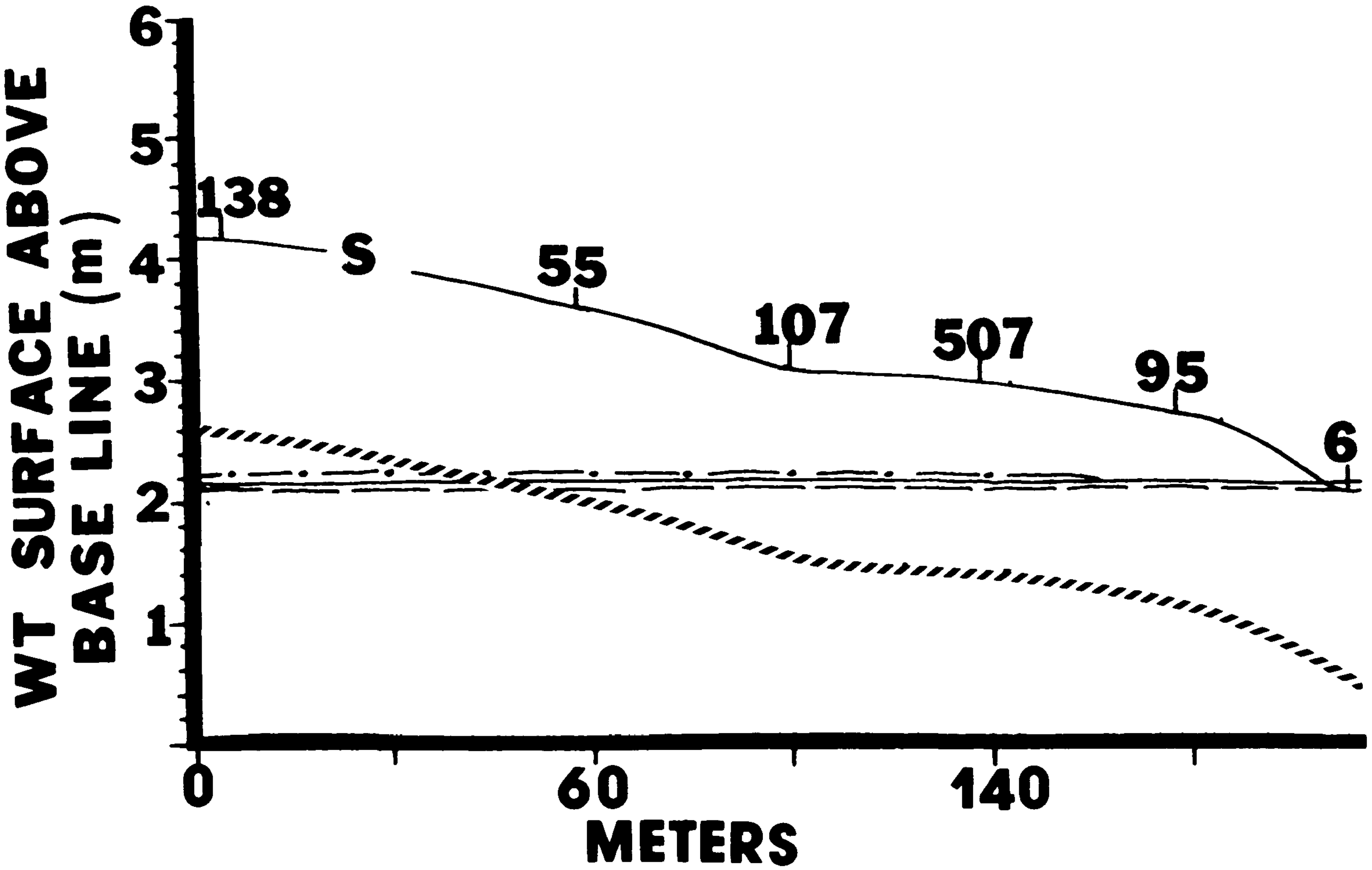


Figure 20. Plot of mean yearly water table depths vs. distance from watershed edge for the undrained traverse [where 138 = Clarion, 55 = Nicollet, 107 = Webster, 507 = Canisteo, 95 = Harps, 6 = Okoboji, (——) = November 1, 1977, through October 31, 1978, (— —) = November 1, 1978, through October 31, 1979, (—·—) = November 1, 1979, through October 31, 1980, (▰▰▰) = 1.6 m depth from soil surface and S = soil surface]

Undrained traverse

Depth and duration of water tables in each of the soil series members of the undrained Clarion toposequence are shown in Figures 14 through 19. Water table plots, duration of study, patterns of water table fluctuations, maximum water table inflections, distance to surface of water table from soil surface relative to distance from watershed boundary, and percent slope were similar to those in the artificially drained traverse.

Two major differences were noted in overall water table depth and duration between the artificially drained and undrained traverses. First, Figure 20 shows that the water table surface was flat throughout the entire undrained traverse. The water table surface in the tile drained traverse was not flat and suggested that water was removed faster from lower areas than the water could move laterally from farther up slope. Second, the water table surface was closer to the soil surface in the undrained traverse than in the artificially drained traverse. Generally, for any point on the undrained traverse, the water table surface was 70 cm closer to the soil surface than at a comparable position on the artificially drained traverse.

Figures 7 through 20 make it possible to estimate depth and duration of water tables for individual sites within either the artificially drained or undrained Clarion toposequence, at least during the duration of this study. For example, Figures 7 through 12, and 14 through 19 show that the water table depth decreased and duration of a high water table increased from Clarion to Okoboji. For soil interpretations, it would be beneficial to be able to predict water table depth and duration for any position along either an artificially drained or undrained traverse.

Water Table Prediction Equations for Individual Soils in Both Traverses

Symbols and identification of selected variables used in the correlation and regression analyses for all soils in the artificially tile drained and undrained traverses are given in Table 3. The means and ranges of these variables used in the analyses for all soils in both traverses are listed in Table 4.

Correlation analysis

Simple (linear) correlation coefficients were computed between the selected variables for each soil in both traverses. Only a few of these correlations were greater than $r = \pm 0.40$. Water table level (WT) was correlated with ANP (antecedent precipitation in the 30 days before WT measurement) only in the Clarion soils in both traverses ($r = 0.42$) and with time of measurement (TDN) in the Canisteo soil, tile-drained traverse ($r = 0.45$). The complex relationships between WT, the dependent variable, and the time and climatic variables are determined in the next sections.

Among the climatic variables, the correlations between ANP and BPW (amount of percolating water) varied from 0.32 to 0.42 in the different soils, all correlations between ANP and CP (amount of precipitation between WT measurements) were 0.74, all correlations between ANP and EV (amount of evapotranspiration) were 0.44; and the correlations between CP and DB (number of days between WT measurements) varied from 0.54 to 0.57.

Table 3. Symbols and identification of selected variables used in the correlation and regression analysis for all soils in the drained and undrained traverses

Symbol	Variable
TDN	Time (or date in the year) of water table measurement coded from 1 to 364 where January 1 = 1 and December 30 = 364
WT	Water table measurement above base line (m)
BPW	Amount of water (cm) percolating below 1.5 m between WT measurements
ANP	Amount of antecedent moisture (cm) received during the 1 - 30 days prior to WT measurement
CP	Amount of moisture (cm) received between WT measurements
DB	Number of days between WT measurements
EV	Amount of evapotranspiration (cm) during the 1 - 30 days prior to WT measurement

The only independent variables with r-values $>\pm 0.50$ were ANP and CP and CP and DB. These high correlations were expected because the same precipitation data were used for both traverses and the days between water table measurements were similar within each year but varied from year to year. Including both highly correlated variables in the regression model will distort the regression coefficient values (Henao, 1976). Therefore, alternate models were run. One model included all variables listed in Table 3 except ANP, while the second model included all except CP. In both traverses, the higher R^2 occurred in the alternate models including the ANP variable. Therefore, the CP variable was deleted from

Table 4. Means and ranges of selected variables used in the correlation and regression analysis for all soils in the drained and undrained traverses

		Means and ranges of selected variables[a]			
		WT (m)		TDN (days)	DB (days)
Soil	Traverse	Mean	Range	Mean	Mean
Clarion	Drained	5.5	4.3-6.7	187.1	15.5
	Undrained	3.7	2.7-5.0	185.4	14.7
Nicollet	Drained	4.8	3.5-5.5	185.4	15.5
	Undrained	4.1	3.3-4.7	185.3	14.7
Webster	Drained	4.4	4.0-4.7	185.4	15.5
	Undrained	3.7	3.0-4.4	185.3	14.7
Canisteo	Drained	4.3	4.0-4.6	185.4	15.5
	Undrained	3.9	3.1-4.5	185.3	14.7
Harps	Drained	3.9	3.3-4.4	185.5	15.5
	Undrained	3.9	3.1-4.4	185.4	14.7
Okoboji	Drained	3.8	.4-4.2	180.6	15.5
	Undrained	3.7	3.0-4.2	185.4	14.7

[a]Ranges for all variables except WT are the same for all soils in both traverses, as follows: TDN=8-364, BPW=0-7.8, ANP=0.2-30.7, CP=0-30.6, DB=5-43, EV=0-9.4; means for all variables except WT, TDN, and DB are the same for all soils in both traverses as follows: BPW=0.4, ANP=6.7, CP=3.5, and EV=1.5

all subsequent models; its deletion also eliminated the high correlation between CP and DB in subsequent models. Salih (1979) explained the techniques used to select the better one of two highly correlated variables.

Although variables were selected to eliminate the high linear correlations between variables, considerable intercorrelation remained because of curvilinear relationships between variables such as TDN (time of year) and the climatic variables of ANP and EV. These intercorrelations complicated the procedure of selecting variates for the final regression models and of interpretation of variable effects on WT. Since this statistical analysis involved uncontrolled variables operating in a natural system where soil properties and climate vary, this difficulty was expected.

Multiple regression analysis

Because the water table level (WT) fluctuated curvilinearly during the year (Figures 7 through 12 and 14 through 19), variates for the cubic function of time of year (TDN, TDN^2, and TDN^3) were included in the initial models for predicting WT. The other variables were included as quadratic functions (X_i and X_i^2 variates). All possible linear*linear interactions between the independent variables were also included. The higher-order interactions between TDN^2 and TDN^3 and the linear functions of the other variables (TDN^2*X_i and TDN^3*X_i) were included in the initial models. These were included to account for the year-to-year differences, because of weather variations, in the magnitudes of the maximum and minimum WT levels and the times during the year when they occurred. The variates included in the initial models of WT levels in all individual soils in the drained and undrained traverses are listed in Table 5.

The WT prediction models for individual soils in both traverses were computed to determine which variates were most important for predicting the water table level. Since the number of WT observations for each soil varied from 70 to 71 in the 3 years, the initial models with

Table 5. Variates included in the multiple regressions of WT on the linear, quadratic, and cubic functions of selected variables for all soils in the drained and undrained traverses[a]

X_i	Variate	X_i	Variate
1	TDN	16	TDN^2
2	ANP	17	ANP^2
3	DB	18	DB^2
4	EV	19	EV^2
5	BPW	20	BPW^2
6	TDN*ANP	21	TDN^2*ANP
7	*DB	22	*DB
8	*EV	23	*EV
9	*BPW	24	*BPW
10	ANP*DB	25	TDN^3
11	*EV		
12	*BPW		
13	DB*EV	26	TDN^3*ANP
14	*BPW	27	*DB
		28	*EV
15	EV*BPW	29	*BPW

[a]WT is the dependent (Y) variable.

29 variates were overloaded, that is, too many variates were present for the available number of observations. Many of the terms were deleted, however, because of nonsignificance during the model selection process so that most final models were not overloaded. The final prediction models will be presented and discussed in the following sections, first for the soils in the artificially drained traverse and then for those in the undrained traverse.

Artificially drained traverse   The R^2 values of the initial or complete prediction models, which included all variates listed in Table 5, and of the final models for all soils are given in Table 6. The stepwise, backward elimination of nonsignificant variates in the model selection procedure is illustrated for the Clarion soil in Table 6. For all others, only the R^2 values and number of variates of the complete and final models are given. The regression coefficients and their significance level are given in Table 7 for the variates selected in the final models for all soils.

Clarion   The complete prediction model for the Clarion soil had an R^2 of 0.78 (Table 6). Therefore, about 78% of the variation in WT level was explained by the 29 variates in this model. After deleting nine nonsignificant variates stepwise, the final prediction model contained 20 variates and had an R^2 of 0.74. This model is overloaded but since all remaining higher-order interactions were significant at the 15% level, the backward selection was stopped at this point.

The variates retained in the WT prediction model for Clarion (Table 7) included the cubic function of TDN, two TDN^3*X_i interactions, four

Table 6. Model selection steps for soils in the drained traverse

Soil	Model no.	No. of X variates	Model selection steps	R^2
Clarion	C1D	29	Complete prediction model; all variates listed in Table 5	.778
	C2D to C9D	28 to 21	Deleted TDN^3*BPW, TDN^3*ANP, ANP*DB, DB*BPW, EV*BPW, DB^2, ANP^2, and EV^2 stepwise from Model C1D	.744 to .750
	C10D	20	Deleted BPW^2 from C9D; final prediction model	.743
Nicollet	N1D	29	Complete prediction model; all variates listed in Table 5	.556
	N12D	17	Deleted 12 variates stepwise from N1D; final prediction model	.519
Webster	W1D	29	Complete prediction model; all variates listed in Table 5	.739
	W15D	14	Deleted 15 variates stepwise from W1D; final prediction model	.603
Canisteo	CA1D	29	Complete prediction model; all variates listed in Table 5	.612
	CA18D	14	Deleted 15 variates stepwise from CAID; final prediction model	.555
Harps	H1D	29	Complete prediction model; all variates listed in Table 5	.592
	H19D	11	Deleted 18 variates stepwise from H1D; final prediction model	.512
Okoboji	O1D	29	Complete prediction model; all variates listed in Table 5	.593
	O18D	11	Deleted 18 variates stepwise from O1D; final prediction model	.510

Table 7. Regression statistics of WT on selected variates, final models for soils in the drained traverse

Variate[a]	Regression coefficients (b_i)[b]		
	Clarion	Nicollet	Webster
TDN	-0.0265*	-0.00249	-0.000350
ANP	-0.1324	-0.1807++	0.04065**
DB	0.0223	0.00223	0.00285*
EV	-3.914	1.753**	-1.744**
BPW	3.935*	0.9792	-4.190*
TDN*ANP	0.003812*	0.002646*	--
*DB	0.000750	0.0001686**	--
*EV	0.07462+	-0.01707**	0.02963**
*BPW	0.04552*	-0.01745	0.08760*
ANP*EV	0.0297**	-0.0124	--
*BPW	0.0680**	--	--
DB*EV	--	-0.00934**	--
EV*BPW	--	0.1000++	--
TDN^2	0.0002167**	5.2939E-06	5.2526E-06
ANP^2	--	--	-0.00216**
EV^2	--	0.0343*	--
TDN^2*ANP	-1.1166E-05**	-7.3901E-06*	--
*DB	-9.5339E-06*	--	--
*EV	-0.0004153++	3.9298E-05**	-0.0001599**
*BPW	0.0001546*	5.4261E-05	-0.0005908*
TDN^3	-4.0622E-07**	--	-9.8300E-09
TDN^3*DB	2.3285E-08**	--	--
*EV	7.2326E-07++	--	2.7407E-07**
*BPW	--	--	1.2945E-06*
Intercept	4.886**	4.776**	4.234**
R^2	0.743**	0.519**	0.602**

[a]Rounded means and ranges of the variables are shown in Table 4.

[b]For very small coefficients, the negative exponent is shown; for example, -1.12E-05 = $-1.12*10^{-5}$.

**, *, ++, +Significance at the 1%, 5%, 10%, and 15% levels, respectively, in this and all subsequent tables.

Table 7. (Continued)

Variate	Regression coefficients (b_i)		
	Canisteo	Harps	Okoboji
TDN	0.00558*	0.00315	0.00281
ANP	--	0.0152	-0.583**
DB	0.00772	0.0125**	--
EV	-0.566	-0.819	-0.207**
BPW	0.0180	--	0.334*
TDN*ANP	--	--	0.008540**
*DB	-0.0002024	--	--
*EV	0.01064	0.01643	--
*BPW	--	--	-0.002441^{++}
ANP*DB	--	-0.000814*	--
*EV	--	0.00343	--
TDN^2	-2.5897E-05^{++}	-5.0449E-06	-2.5097E-05
EV^2	--	--	0.0221*
TDN^2*ANP	--	--	-3.7334E-05**
*DB	1.5427E-06^{+}	--	--
*EV	-6.3574E-05^{++}	-0.0001028^{++}	--
TDN^3	3.8247E-08	-2.3864E-09	4.0615E-08
TDN^3*ANP	--	--	5.1547E-08**
*DB	-2.9642E-09^{++}	--	--
*EV	1.1765E-07^{++}	1.9442E-07*	--
Intercept	3.826**	3.392**	4.129**
R^2	0.555**	0.512**	0.510**

TDN^2*X_i and four $TDN*X_i$ interactions. Thus, the time of year when the WT was measured had a significant cubic effect on WT level modified by interactions with all other variables. The effects of the other variables on WT level were primarily through their interactions with TDN although ANP had highly significant interactions with EV (evapotranspiration) and BPW (percolating water below 1.5 m).

Nicollet The complete prediction equation had an R^2 of 0.56; the final model with 17 variates had an R^2 of 0.52 (Table 6). The final R^2 was low compared with those for the adjacent soils of Clarion and Webster. Time (TDN) had only a quadratic effect on WT in Nicollet but this effect was modified by interactions with all other variables (Table 7). ANP had a linear effect on WT modified by interactions with TDN. EV had a quadratic effect on WT modified by strong interactions with TDN and DB. The effects of DB and BPW on WT were primarily through their interactions with TDN and EV.

Webster The R^2 values were 0.74 and 0.60 for the initial and final models, respectively (Table 6). Time (TDN) had a cubic effect on WT level modified by strong interactions with only EV and BPW (Table 7). Antecedent precipitation (ANP), which had interaction effects on WT in the Clarion and Nicollet soils, had only a marked quadratic effect in the Webster. The EV and BPW variables had linear effects on WT modified by strong interactions with all three components of TDN. DB had only a weak linear effect on WT.

Canisteo The final model for Canisteo had 14 variates and an R^2 of 0.56 (Table 6). TDN was the only variate significant at the

5% level. Time (TDN) had a weak cubic effect on WT level modified by weak interactions with DB and EV. The DB and EV variables had a weak linear effect on WT primarily through their weak interactions with TDN. BPW had little effect and ANP had no effect on WT in Canisteo.

Harps The R^2 of the final model with 11 variates was 0.51 (Table 6) which was less than that for the adjacent Canisteo. Significance levels of the variates in both the Harps and Canisteo final models were much less than in the Clarion, Nicollet, and Webster models (Table 7). TDN had a weak cubic effect on WT primarily through its interactions with EV. The effect of ANP on WT was primarily through its interaction with DB. Effect of EV on WT was mostly in its interactions with TDN. DB had a strong linear effect on WT modified by ANP.

Okoboji Although the R^2 of the final model for Okoboji was the same as that for Harps (Table 6), the variates had considerably higher significance in the Okoboji final model. TDN had a cubic effect on WT modified by strong interactions with ANP. The ANP variable had a strong linear and interaction effect with TDN on WT level. EV had a strong quadratic effect and BPW had primarily a linear effect on WT. The effects of the variables on WT levels were considerably different in the adjacent Harps and Okoboji soils.

Summary The mix of variates retained in the final regression models varied widely among soils (Table 7). Significance levels of the retained variates also varied widely, as shown in Table 8. The final model for Clarion had the most significant variates while those for Canisteo and Harps had the least.

Table 8. Significance levels of the regression coefficients in the final WT prediction models for the soils in the drained traverse

	Significance levels of the b_i in final models for the following soils					
Variate	Clarion	Nicollet	Webster	Canisteo	Harps	Okoboji
TDN	*	--[a]	--	*	--	--
ANP	--	++	**	--	--	**
DB	--	--	*	--	**	--
EV	--	**	**	--	--	**
BPW	*	--	*	--	--	*
TDN*ANP	*	*	--	--	--	**
*DB	--	**	--	--	--	--
*EV	+	**	**	--	--	--
*BPW	*	--	*	--	--	++
ANP*DB	--	--	--	--	*	--
*EV	**	--	--	--	--	--
*BPW	**	--	--	--	--	--
DB*EV	--	**	--	--	--	--
EV*BPW	--	++	--	--	--	--
TDN^2	**	--	--	++	--	--
ANP^2	--	--	**	--	--	--
EV^2	--	*	--	--	--	*
TDN^2*ANP	**	*	--	--	--	**
*DB	*	--	--	+	--	--
*EV	++	**	**	++	++	--
*BPW	*	--	*	--	--	--
TDN^3	**	--	--	--	--	--
TDN^3*ANP	--	--	--	--	--	**
*DB	**	--	--	++	--	--
*EV	++	--	**	++	*	--
*BPW	--	--	*	--	--	--

[a]Not significant at the 15% level if undesignated.

Time (TDN) had a cubic effect on WT level in all except the Nicollet soil, but this effect was strong in the Clarion soil and weak in the Canisteo and Harps soils. The cubic effect of TDN was expressed primarily through its higher order interactions with one or more of the other variables.

The effect of antecedent precipitation (ANP) on WT level was variable. It had a large effect through its interactions in the Clarion, Nicollet, and Okoboji soils, a large quadratic effect without interaction in the Webster soil, and small effect in the Canisteo and Harps soils.

Evapotranspiration (EV) had a strong effect on WT, either through its quadratic function or interactions with TDN, in all soils except Canisteo and Harps. Percolating water below 1.5 m (BPW) had some effect on WT level in the Clarion, Webster, and Okoboji soils, very little effect in Nicollet, and none in Canisteo and Harps. Days between sampling (DB) which was included to account for different sampling times in the 3 years, had some effect on WT in all soils except Okoboji.

Although the effects of all variables on WT levels were inconsistent among soils, all had varying significant effects in most soils. For this reason, all will be tested in the prediction equations based on the combined data from all soils.

Undrained traverse The R^2 values of the initial or complete prediction models, which included all variates listed in Table 5, and of the final models for all soils are given in Table 9. The regression statistics of the final models for all soils are given in Table 10.

Table 9. Model selection steps for soils in the undrained traverse

Soil	Model no.	No. of X variates	Model selection steps	R^2
Clarion	C1U	29	Complete prediction model; all variates listed in Table 5	.689
	C12U	13	Deleted 16 variates stepwise from C1U; final prediction model	.659
Nicollet	N1U	29	Complete prediction model; all variates listed in Table 5	.831
	N9U	17	Deleted 12 variates stepwise from N1U; final prediction model	.778
Webster	W1U	29	Complete prediction model; all variates listed in Table 5	.678
	W8U	21	Deleted 8 variates stepwise from W1U; final prediction model	.657
Canisteo	CA1U	29	Complete prediction model; all variates listed in Table 5	.481
	CA14U	9	Deleted 20 variates stepwise from CA1U; final prediction model	.404
Harps	H1U	29	Complete prediction model; all variates listed in Table 5	.628
Harps	H13U	14	Deleted 15 variates stepwise from H1U; final prediction model	.551
Okoboji	O1U	29	Complete prediction model; all variates listed in Table 5	.560
	O10U	18	Deleted 11 variates stepwise from O1U; final prediction model	.502

Table 10. Regression statistics of WT on selected variates, final models for soils in the undrained traverse

Variate[a]	Regression coefficients (b_i)[b]		
	Clarion	Nicollet	Webster
TDN	-0.00914	-0.00752**	0.00283
ANP	0.0207	0.0982**	-0.1369+
DB	0.1158**	0.0145**	0.1215**
EV	1.931**	-6.809**	-4.022*
BPW	-0.1330*	-14.528**	1.217**
TDN*ANP	0.001355	-0.000344**	0.002447+
*DB	--	--	-0.000708++
*EV	-0.01771**	0.1096**	0.06204*
*BPW	--	0.3204**	-0.005409**
ANP*DB	-0.00304*	-0.00133*	--
*BPW	--	-0.0689**	--
DB*BPW	--	-0.0185**	--
TDN^2	0.000155*	6.4199E-05**	1.5013E-05
ANP^2	--	--	0.00125+
DB^2	-0.00175*	--	-0.00184**
BPW^2	--	--	-0.0776**
TDN^2*ANP	-4.8520E-06++	--	-1.5143E-05++
*DB	--	--	4.6680E-06++
*EV	3.7528E-05**	-0.0005629**	-0.0003165*
*BPW	--	-0.002119**	--
TDN^3	-2.3610E-07*	-1.1163E-07**	-4.3842E-08
TDN^3*ANP	--	--	2.7406E-08*
*DB	--	--	-9.6744E-09*
*EV	--	9.2410E-07**	5.2477E-07**
*BPW	--	4.5530E-06**	--
Intercept	2.107**	3.726**	2.587**
R^2	0.659**	0.778**	0.657**

[a]Rounded means and ranges of the variables are shown in Table 4.

[b]For very small coefficients, the negative exponent is shown; for example, -4.85E-06 = -4.85×10^{-6}.

Table 10. (Continued)

Variate	Regression coefficients (b_i) Canisteo	Harps	Okoboji
TDN	0.00608**	0.01206**	0.00371
ANP	0.03782**	0.02257	-0.153+
DB	0.00700*	0.01702*	-0.00658
EV	-0.04545**	0.14609	0.44987+
BPW	0.29584	0.10187++	0.422*
TDN ANP	-0.00020*	-0.00010	0.002407+
DB	--	-0.00020*	-8.2485E-05++
EV	--	-0.00269++	-0.00524+
BPW	-0.00136*	--	--
ANP BPW	--	--	-0.0329
DB EV	--	--	-0.00325
TDN^2	-1.14992E-05**	-4.866756E-05*	8.636428E-06
ANP^2	--	--	0.00268++
DB	--	--	0.00071+
EV	--	0.01643	0.02182
BPW^2	-0.0168+	-0.01240	--
TDN^2 ANP	-0.00020	--	-1.42218E-05++
DB	--	4.554677E-07++	--
EV	--	5.690426E-06+	1.1849E-05++
TDN^3	--	5.911537E-08++	-4.1957E-08
TDN^3 ANP	--	--	2.503E-08++
Intercept	3.332**	3.202**	3.427**
R^2	0.404**	0.551**	0.502**

Clarion The final model for the Clarion soil had 13 variates and an R^2 of 0.66 (Table 9). Time of sampling (TDN) had a cubic effect on WT level modified by interactions with EV and weak ones with ANP (Table 10). Of the other variables, ANP had a slight effect on WT level, DB had primarily a quadratic effect, EV had an effect primarily through its interactions with TDN, and BPW had only a linear effect on WT level. All variables had a less significant effect on the WT level in the undrained Clarion than in the drained Clarion (Table 7).

Nicollet The final model had 17 variates and an R^2 of 0.78 (Table 9) which was much larger than the R^2 of 0.52 of the final model for the drained Nicollet (Table 6). Time (TDN) had a strong cubic effect on WT modified by highly significant interactions with EV and BPW (Table 10). In the drained Nicollet, TDN had only a quadratic effect on WT (Table 7). The effect of EV on WT was primarily through its three highly significant interactions with all components of the cubic function of TDN. All other variables had highly significant linear effects on WT modified by interactions with two or three of the other variables.

Webster The final Webster model had 21 variates and an R^2 of 0.66 (Table 9). With 21 variates, this model was overloaded but several variates were retained because their higher-order interactions were significant (Table 10). The cubic effect of TDN on WT level was primarily through its interactions with ANP, DB, and EV. All other variables had significant quadratic or linear effects on WT modified by interactions only with TDN. The R^2 of the final model and number of significant variates were higher in the undrained than in the drained

Webster (Tables 7 and 10).

<u>Canisteo</u> The final model for undrained Canisteo had only nine variates and an R^2 of 0.40 (Table 9). Time (TDN) had a quadratic effect on WT level modified only by linear linear interactions with ANP and BPW (Table 10). The other variables had primarily linear effects on WT except BPW which had a weak quadratic effect on WT level. The effects of the variates on WT in the undrained Canisteo had more significance than in the drained Canisteo (Table 7) although the R^2 was less for this model than for the one for drained Canisteo.

<u>Harps</u> The undrained Harps final model had 14 variates and an R^2 of 0.55 (Table 9). TDN had a cubic effect on WT level modified by weak interactions with DB and EV (Table 10). Of the other variables, ANP had a slight effect on WT, BPW had only a weak quadratic effect, DB had a linear effect modified by interactions with TDN, and EV had a strong quadratic effect on WT level modified by weak interactions with TDN.

<u>Okoboji</u> The final model for undrained Okoboji had 18 variates and an R^2 of 0.50 (Table 9). Most of the variates were significant at the 10% and 15% levels (Table 10). TDN had a weak cubic effect on WT level modified by interactions with ANP and EV. All other variables except TBW had quadratic effects on WT modified by one or more interactions with other variables. BPW had a linear effect on WT plus an interaction with ANP.

<u>Summary</u> The variates retained in the final models of the undrained soils varied among the soils (Table 10). Significance levels of the variates also varied, as summarized in Table 11. The linear and

Table 11. Significance levels of the regression coefficients in the final WT prediction models for the soils in the undrained traverse

Variate	Significance levels of the b_i in final models for the following soils					
	Clarion	Nicollet	Webster	Canisteo	Harps	Okoboji
TDN	--[a]	**	--	**	**	--
ANP	--	**	+	*	--	+
DB	**	**	**	*	*	--
EV	**	**	*	**	--	+
BPW	*	**	**	++	++	*
TDN*ANP	--	**	+	*	--	+
*DB	--	--	++	--	*	++
*EV	**	**	*	--	++	++
*BPW	--	**	**	+	--	--
ANP*DB	*	*	--	--	--	--
*BPW	--	**	--	--	--	*
DB*BPW	--	**	--	--	--	--
TDN^2	*	**	--	**	*	--
ANP^2	--	--	+	--	--	++
DB^2	*	--	**	--	--	+
EV^2	--	--	--	--	**	*
BPW^2	--	--	**	+	++	--
TDN^2*ANP	++	--	++	--	--	++
*DB	--	--	++	--	++	--
*EV	**	**	*	--	+	++
*BPW	--	**	--	--	--	--
TDN^3	*	**	--	--	++	--
TDN^3*ANP	--	--	*	--	--	++
*DB	--	--	*	--	--	--
*EV	--	**	**	--	--	--
*BPW	--	**	--	--	--	--

[a]Not significant at the 15% level if undesignated.

quadratic effects of the variables had more significance in the models for the undrained soils than for the drained soils (Tables 8 and 11).

Time (TDN) had a strong cubic effect on WT level modified by interactions in the Nicollet and Webster soils, a weak cubic effect in the Clarion, Harps, and Okoboji soils, and only a quadratic effect with little interaction in the Canisteo soil.

Antecedent precipitation (ANP) had none to slight effect on WT in the Clarion and Harps soils, a linear effect plus an interaction effect in Canisteo, and a greater effect on WT in the other soils. EV had linear or quadratic effects on WT modified by interactions with TDN in all soils except Canisteo in which it had only a linear effect on WT level. BPW had primarily a linear or quadratic effect on WT in the Clarion, Canisteo, Harps, and Okoboji soils but was involved in highly significant but variable effects on.WT in all soils.

All variables had varying but significant effects on WT level in most undrained soils, just as occurred in the drained soils. All will be tested in prediction equations based on combining observations from all soils.

Water Table Prediction Equations for All Soils within Each Traverse

The data from all soils within each of the drained and undrained traverses were combined to develop water table prediction equations for each Clarion toposequence. Two additional variables, besides those listed in Table 3, were included to account for the position of each soil in the toposequence or traverse. These were SD (distance in meters from the top edge of the watershed to the soil site) and SL (percent slope at the soil site). The symbols, means, and ranges of the variables used in the combined correlation and regression analysis of all soils in the drained and undrained traverses are listed in Table 12. Simple correlation coefficients greater than ± 0.34 between selected variables for the two traverses are shown in Table 13. These show that SD (site distance) and SL (slope of site) and ANP and CP were highly correlated. The procedure outlined by Salih (1979) was used to run alternate models to determine which of the pair of highly correlated variables should be retained. Higher R^2 values occurred with the ANP and SL variables in the models for both traverses. Therefore, CP and SD were deleted from all regressions.

Artificially drained traverse

All 38 variates listed in Tables 5 and 14 were included in the initial complete regression model of all soils in the drained traverse. Again, in order to fit the water table level (WT) to curvilinear changes with time of year, the TDN, TDN^2, and TDN^3 variates (cubic function of TDN) and all possible interactions involving these variates were included in the initial model. There were about 11 observations per term in this model.

The initial model had an R^2 of 0.744 while the final model with 17 variates had an R^2 of 0.734 (Table 15). The regression statistics of the final prediction model are given in Table 16. The effects of the variables on WT level will be discussed in the following subsections.

Table 12. Symbols, means, and ranges of selected variables used in the combined correlation and regression analysis of all soils in the drained and undrained traverses

Variable	Drained		Undrained	
	Mean	Range	Mean	Range
TDN (coded days)	184.5	8-364	185.3	8-364
WT (m)	4.44	0.4-6.7	3.86	2.7-5.0
BPW (cm)	0.44	0-7.8	0.43	0-7.8
ANP (cm)	6.65	0.2-30.6	6.70	0.2-30.7
CP (cm)	3.52	0-30.6	3.52	0-30.6
DB (days)	15.5	5-43	14.7	1-41
EV (cm)	1.64	0-9.4	1.63	0-9.4
SD (m)	87.1	9-171	101.5	9-177
SL (%)	1.5	0-4	1.5	0-4

Table 13. Simple correlation coefficients greater than ±0.34 between selected variables for combined soils in the drained and undrained traverses

Between variables	r-value[a]	
	Drained	Undrained
WT and SD	-.74	--
and SL	.78	--
SD and SL	-.90	-.94
BPW and ANP	.42	.35
and CP	.38	--
ANP and CP	.74	.74
and EV	.44	.44
CP and DB	.57	.56
and EV	.39	.39

[a]Based on 420 and 426 observations in the drained and undrained traverses, respectively.

Table 14. Variates added to the previously-used variates for the multiple regressions of WT on selected variables for all soils combined in each of the drained and undrained traverses[a]

X_i	Variate	X_i	Variate
1	SL	7	SL^2
2	TDN*SL	8	TDN^2*SL
3	SL*BPW	9	TDN^3*SL
4	*ANP		
5	*DB		
6	*EV		

[a]All variates listed in Table 5 were also included in the initial regression analyses.

Table 15. Model selection steps for combined soils in drained and undrained traverses

Traverse	Model no.	No. of X variates	Model selection steps	R^2
Drained	DT1	38	Complete prediction model, all variates listed in Tables 5 and 14	.744
	DT15	17	Deleted 21 variates stepwise from Model DT1; final prediction model	.734
Undrained	UT1	38	Complete prediction model, all variates listed in Tables 5 and 14	.453
	UT11	22	Deleted 16 variates stepwise from Model UT1; final prediction model	.442

Table 16. Regression statistics of WT on selected variates, final models for soils in drained and undrained traverses

Variate	Regression coefficients (b_i) Drained	Undrained
TDN	0.0008564	-0.002502
SL	0.0937*	0.0642
BPW	-0.0445*	0.0726++
ANP	-0.00564	-0.0762+
DB	0.0107++	0.0426**
EV	0.6474**	0.7375**
TDN*SL	0.003299**	0.001004
*ANP	0.000438	0.001881*
*DB	-0.000229**	-8.2383E-05**
*EV	-0.00631**	-0.00786**
SL*DB	0.00511**	0.00326*
TDN^2	-1.3662E-06	3.1471E-05+
SL^2	--	-0.0574**
BPW^2	--	-0.0152*
DB^2	--	-0.000665**
EV^2	0.00998++	0.0110*
TDN^2*SL	-7.6374E-06**	8.2030E-06
*ANP	-1.5533E-06++	-1.0926E-05**
*DB	7.6407E-07**	--
*EV	1.2986E-05**	1.7436E-05**
TDN^3	--	-5.5650E-08+
TDN^3*SL	--	-3.1724E-08*
*ANP	--	1.7812E-08**
Intercept	3.659**	3.267**
R^2	0.734**	0.441**

SL Slope of the site had a linear effect on WT level modified by strong interactions with TDN and DB (Table 16). The partial derivative of WT with respect to (w.r.t.) SL is:

$$dWT/dSL = 0.0937 + 0.00330\ TDN - 7.637E\text{-}06\ TDN^2 + 0.00511\ DB. \quad (1)$$

At DB = 15 days, equation 1 simplifies to:

$$dWT/dSL = 0.170 + 0.00330\ TDN - 7.637E\text{-}06\ TDN^2. \quad (2)$$

Equation 2 shows that the linear slope of the WT response to the slope variable varied curvilinearly (in a quadratic way) with increasing TDN.

The partial derivative of equation 2 w.r.t. TDN is:

$$d(dWT/dSL)/dTDN = 0.00330 - 1.527E\text{-}05\ TDN. \quad (3)$$

If equation 3 is set equal to 0 and solved for TDN, the TDN value is the one associated with the maximum slope of the linear WT response to the SL variable. This occurred at TDN = 216 or, decoded, Aug. 4.

Substituting TDN values of 100, 200, 216, and 300 into the simplified derivative in equation 2 gave slopes of 0.424, 0.525, 0.527, and 0.473, respectively. These slopes showed that WT level increased from 0.42 to 0.53 to 0.47 m per 1% SL change as TDN increased from 100 to 300. The effect of increasing SL on WT level was in the right direction (Figure 13) but the magnitude appeared too high. These changes, as computed by the partial derivative, were at mean levels of the ANP, BPW, and EV variables. If the entire prediction equation is used and typical values of ANP, BPW, and EV for various times (TDN) used in the equation, the effect of SL on WT level at different TDN levels probably will be less. If joint effects are present due to intercorrelations, it is unrealist·· to vary one variable over its range and hold others constant; this may give a distorted relationship. Salih (1980) discussed and illustrated these distorted relationships due to intercorrelations.

BPW The BPW variable (net percolating water below 1.5 m between WT measurements) had only a negative, linear effect on WT level (Table 16). Its regression coefficient of -0.045 showed that the WT decreased 0.045 m per 1 cm increase in BPW. The effect of BPW is in the right direction but its magnitude may be distorted because of the joint effects previously mentioned and lack of a significant interaction with DB (to be discussed in the DB subsection).

ANP Antecedent precipitation had a weak effect on WT level primarily through its interactions with TDN (Table 16). The partial derivative of WT w.r.t. ANP is:

$$dWT/dANP = -0.00564 + 0.000438\ TDN - 1.553E\text{-}06\ TDN^2. \tag{4}$$

As computed from the partial derivative of equation 4 w.r.t. TDN, the TDN value associated with the maximum slope of the linear WT response to ANP was 141 or, decoded, May 21.

Substituting TDN values of 100, 141, 200, and 300 into the partial derivative in equation 4 gave slopes of 0.023, 0.025, 0.020, and -0.014, respectively. These showed that that WT level increased about 0.025 m per 1 cm of ANP in late May and then the effect of ANP decreased until it had a negative effect in the late fall. The effect of ANP on WT level showed the expected trend in that its effect decreased from late May through the summer months as water usage by crops increased; the negative effect in late fall may have been due to a declining WT level during the period when no water moved out of the root zone as the plant-available water was being replenished.

EV Evapotranspiration in the 30 days before the WT measurement had a quadratic effect on WT level modified by strong interactions with TDN (Table 16). The partial derivative of WT w.r.t. EV is:

$$dWT/dEV = 0.6474 + 0.01996\ EV - 0.00631\ TDN + 1.2986E\text{-}05\ TDN^2. \quad (5)$$

As computed from the partial derivative of equation 5 w.r.t. TDN, the TDN value associated with the minimum initial slope (slope at EV = 0) in the quadratic effect of EV on WT was 243 or, decoded, Aug. 31.

Substituting TDN values of 100, 200, 243, and 300 into equation 5 gave the following set of simplified derivatives:

$$\begin{aligned} dWT/dEV &= 0.1463 + 0.01996\ EV\ (\text{at } TDN = 100), \\ &= -0.0952 + 0.01996\ EV\ (\text{at } TDN = 200), \\ &= -0.1188 + 0.01996\ EV\ (\text{at } TDN = 243), \text{ and} \\ &= -0.0769 + 0.01996\ EV\ (\text{at } TDN = 300). \end{aligned} \quad (6)$$

Setting these partial derivatives equal to 0 and solving for EV gave EV values associated with minimum WT level of <0, 4.8, 6.0, and 3.9, respectively. On TDN = 200 (July 19) and TDN = 243 (Aug. 31), minimum WT levels thus occurred at EV = 4.8 and 6.0, respectively.

The effect of EV on WT level was in the expected direction at EV levels less than those associated with the WT minima. Except for one isolated EV of 9, the maximum EV was about 6. The positive effect of

EV on WT in the first part of the year, up to about TDN = 140, was unexpected. This effect may be related to the joint effects of EV and other variables which distort the relationship, as discussed previously in the SL subsection.

DB The DB variable, days between WT measurements, was added to account for the effects of different times between measurements in the 3 years on the variable effects of BPW and CP which were amounts of percolating water and precipitation, respectively, between measurements. The DB variable had a linear effect on WT level modified by strong interactions with TDN and SL (Table 16). The simplified partial derivative of WT w.r.t. DB at SL = 2 is:

$$dWT/dDB = 0.0209 - 0.000229\ TDN + 7.6407E\text{-}07\ TDN^2. \qquad (7)$$

From the partial derivative of equation 7 w.r.t. TDN which then was set equal to 0, the TDN value associated with the minimum slope of the linear WT response to DB was computed to be 150 or, decoded, June 29.

Substituting TDN values of 100, 150, 200, and 300 into equation 7 gave slopes of 0.0056, 0.0038, 0.0057, and 0.0210, respectively. These showed that WT increased 0.0056 to 0.0038 to 0.021 cm per day of DB as TDN increased from 100 to 300. The BPW*DB interaction was expected to account for varying amounts of BPW due to differences between times of WT measurements. The lack of this interaction and presence of interactions between DB and other variables indicated that DB was accounting for some of the year-to-year variations in WT levels. Thus, the DB effect is specific for these 3 years of WT measurements, but DB will not be a good predictor variable for other years.

TDN Time of year (TDN) had a quadratic effect on WT level modified by strong interactons with SL, DB, and EV and weak interactions with ANP (Table 16). The partial derivative of WT w.r.t. TDN is:

$$\begin{aligned} dWT/dTDN = {} & 0.000856 - 2.7324E\text{-}06\ TDN + 0.00330\ SL + \\ & 0.000438\ ANP - 0.000229\ DB - 0.00631\ EV - \\ & 1.5275E\text{-}05\ TDN{*}SL - 3.1066E\text{-}06\ TDN{*}ANP + \\ & 1.5281E\text{-}06\ TDN{*}DB + 2.5972E\text{-}05\ TDN{*}EV. \end{aligned} \tag{8}$$

Thus, the slope of the change in WT level per unit (day) of TDN varied with the levels of the TDN, SL, ANP, DB, and EV variables.

At ANP = 7 cm, DB = 20 days, and EV = 5 cm, the partial derivative in equation 8 in terms of TDN and SL simplified to:

$$\begin{aligned} dWT/dTDN = {} & -0.03221 + 1.3594E\text{-}04\ TDN + \\ & 0.00330\ SL - 1.5275E\text{-}05\ TDN{*}SL. \end{aligned} \tag{9}$$

For SL = 0, 2, and 4, the simplified partial derivative in equation 9 is further simplified to the following set of equations:

$$\begin{aligned} dWT/dTDN &= -0.0322 + 0.0001359\ TDN\ (\text{at } SL = 0), \\ &= -0.0256 + 0.0001054\ TDN\ (\text{at } SL = 2), \text{ and} \\ &= -0.0190 + 0.0000748\ TDN\ (\text{at } SL = 4). \end{aligned} \tag{10}$$

Setting each equation 10 equal to 0 and solving for TDN gave the TDN at the minimum WT level at each SL level. These were TDN = 237, 243, and 254, respectively, or decoded, Aug. 25, Aug. 31, and Sept. 11, respectively.

Varying the fixed levels of ANP and EV in equation 8 changed the

TDN associated with minimum WT level and the differences due to increasing slope. Because so many interactions between TDN and the other variables occurred, the effects of other combinations of TDN and one variable at fixed levels of the other variables on WT level were not shown by the partial derivative method. These can be computed using the method outlined here for the TDN and SL variable combination.

Undrained traverse, all soils

The initial model for all soils in the undrained traverse had an R^2 of 0.45 and the final model with 22 variates had an R^2 of 0.44 (Table 15). This R^2 was much less than that of the final model for the drained traverse although the final model for the undrained traverse had more significant variates. The regression statistics of the final prediction model for the undrained traverse are given in Table 16. The effects of the variables on WT level will be discussed briefly.

SL Slope of the site had a quadratic effect on WT modified by an interaction with DB and weak interactions with TDN (Table 16). The partial derivative of WT w.r.t. SL is:

$$dWT/dSL = 0.0642 - 0.1148\ SL + 0.00326\ DB + 0.00104\ TDN + 8.2030E\text{-}06\ TDN^2 - 3.1724E\text{-}08\ TDN^3. \qquad (11)$$

The mathematics of the interaction effects of TDN on the quadratic response of WT on SL will not be presented. As shown by equation 11, the initial slope (at SL = 0) of the quadratic response of WT on the SL variable and the SL values associated with maximum WT level varied in a cubic manner as TDN increased over its range. In the final model for the drained traverse, the change in slope of the linear response of WT on SL varied in a quadratic manner because only interactions between SL and the quadratic components of TDN were retained. The mathematics and effects of higher-order interactions on the dependent variable were discussed by Salih (1980).

BPW Net percolating water below 1.5 m (BPW) had only a quadratic effect on WT level (Table 16). The dWT/dBPW = 0.0726 - 0.0304 BPW. Maximum WT occurred at BPW = 2.4 cm; as BPW increased above 2.4 cm, it had an increasingly negative effect on WT level. At BPW = 2.4, 4, and 6 cm, the slopes (changes in WT per unit of BPW) were 0, -0.05, and -0.11, respectively. In the final drained model, the slope of the linear response of WT on BPW was -0.045.

ANP Antecedent precipitation had a linear effect on WT level modified by strong interactions with all components of TDN (Table 16). The dWT/dANP = 0.0762 + 0.00188 TDN - 1.0926E-05 TDN^2 + 1.7812E-08 TDN^3. The partial derivative of this equation w.r.t. TDN = 0.00188 - 2.185E-05 TDN + 5.344E-08 TDN^2. Setting this equal to 0 and solving by the quadratic formula gave the two points of TDN = 127 and 282 where the maximum and minimum linear response of WT on ANP occurred over the range of TDN. Substitution of TDN = 100, 127, 200, 282, and 300 into the dWT/dANP equation gave slopes of 0.021, 0.023, 0.006, -0.015, and -0.014, respectively. The effect of ANP on WT level over most of the year was similar in both the undrained and drained traverses.

EV Evapotranspiration (EV) had a quadratic effect on WT level modified by strong interactions with the linear and quadratic components of TDN (Table 16). The dWT/dEV = 0.738 + 0.022 EV - 0.00786 TDN + 1.744E-05 TDN^2. The effect of EV on WT in the undrained traverse was very similar to its effect in the drained traverse which was discussed previously.

DB The DB variable had a quadratic effect on WT level modified by interactions with SL and the linear component of TDN (Table 16). At SL = 2, the simplified dWT/dDB = 0.0491 - 0.00133 DB - 8.238E-05 TDN. At TDN = 100, 200, and 300, maximum WT occurred at DB = 31, 25, and 18, respectively. The effect of DB on WT level was positive over its relevant range. The DB effect on WT was discussed previously in the drained traverse section.

TDN Time of year (TDN) had a cubic effect on WT level modified by L*L interactions with SL, ANP, DB, and EV, Q*L interactions with SL, ANP, and EV, and C*L interactions with SL and ANP (Table 16). Thus, the slope of the change in WT level per unit (day) of TDN varied with TDN, SL, ANP, DB, and EV. The TDN variable had similar effects on WT in this undrained traverse as it had in the drained traverse discussed previously except that its cubic component was not significant in the drained traverse. The complex effects of the cubic function of TDN and its interactions with other variables will be discussed in the next section.

Undrained traverse, two soil groups

To determine why the R^2 of the prediction model for the undrained traverse was so much less than that for the drained traverse, a stepwise procedure was used to combine the soils sequentially using all variates included in the initial models. The initial model R^2 values are listed in Table 17 as the data for each soil were sequentially added to the combined model. The R^2 values showed that the model fit the combined data from the Clarion, Nicollet, and Webster group better than the data from the Canisteo, Harps, and Okoboji group of soils. Therefore, separate regression models were developed for the two groups in the undrained traverse.

The R^2 values of the initial and final regression models are given in Table 18. The final model for the soils in the upper part of the traverse had 19 variates and an R^2 of 0.60; the one for the lower part of the traverse had 19 variates and an R^2 of 0.49. The R^2 for the lower traverse was better than the R^2 of 0.44 for combined data from all soils.

The regression statistics of water table (WT) on selected variates of the final models for both halves of the undrained traverse are given in Table 19. All except one of the retained variates were significant at the 1% level in the final model for the upper half of the traverse. Only 8 of the 19 variates were highly significant in the model for the lower half of the traverse. This difference in significance level of the variates also occurred in the final models for individual soils (Table 11).

All linear and $TDN*X_i$ interactions were retained in both models (Table 19), but the mix of squared and other interaction variates varied in the two models. The cubic effect of TDN on WT level was more marked in the soils in the upper than in the lower half of the traverse. In the final model for all soils (Table 16), the BPW variable had only a

Table 17. Initial model R^2 as soils in the undrained traverse were sequentially added to the regression

Soils	R^2
Clarion + Nicollet	0.67
Clarion + Nicollet + Webster	0.62
Clarion + Nicollet + Webster + Canisteo	0.53
Clarion + Nicollet + Webster + Canisteo + Harps	0.50
Clarion + Nicollet + Webster + Canisteo + Harps + Okoboji	0.45

Table 18. Model selection steps for the soils in the upper and lower half of the undrained traverse

Soils	Model no.	No. of X variates	Model selection steps	R^2
Clarion Nicollet Webster	UU1	38	Complete prediction model; all variates in Tables 5 and 14	.620
	UU11	19	Deleted 19 variates stepwise; final prediction model	.596
Canisteo Harps Okoboji	UL1	38	Complete prediction model; all variates in Tables 5 and 14	.501
	UL10	19	Deleted 19 variates stepwise; final prediction model	.486

Table 19. Regression statistics of WT on selected variates, final models for upper and lower halves of undrained traverse

Variate	Regression coefficients (b_i) Clarion, Nicollet, and Webster soils	Canisteo, Harps and Okoboji soils
TDN	-0.01723**	0.005942*
SL	0.5247**	0.2368**
BPW	0.7739**	0.6232++
ANP	0.07089**	-0.07023+
DB	0.07596**	0.01384**
EV	-3.06811*	0.3896**
TDN*SL	0.0056186**	-3.0358E-04
*BPW	-0.0034682**	-0.0092690**
*ANP	-2.9765E-04**	0.0016538*
*DB	-8.3117E-05**	-6.7344E-05**
*EV	0.053332**	-0.0048679**
BPW*EV	--	0.02291+
TDN^2	1.0575E-04**	-6.7560E-06
SL^2	-0.1700**	--
BPW^2	-0.05196**	--
DB^2	-0.001263**	--
EV^2	--	0.009906*
TDN^2*SL	-1.4843E-05**	--
*BPW	--	2.96279E-05*
*ANP	--	-1.00982E-05*
*EV	-2.9178E-04**	1.13871E-05**
TDN^3	-1.50724E-07**	-1.32703E-08
TDN^3*ANP	--	1.77288E-08**
*EV	5.02934E-07**	--
Intercept	2.733**	3.163**
R^2	0.595**	0.486**

quadratic effect on WT; in the models for both halves of the traverse, BPW had one or more interaction effects on WT (Table 19). The SL*DB and TDN^3*SL interactions, significant in the all-soils model, had no significance in either model for the two groups of soils. The TDN^3*EV interaction, which had no significance in the all-soils model, however, was significant in the model for soils in the upper half of the traverse.

The effects of the variables and their interactions on WT level will be discussed and illustrated in the next subsections. The values for WT levels at selected combinations of two variables with the others held constant were predicted from the regression equations in Table 19. A computer program was written in which all regression coefficients in the prediction equation were entered into the computer, selected combinations of TDN and one other variable were listed for which the WT level of each combination was computed and printed, and other variables were held constant. The relationships between WT level and TDN and an interacting variable were plotted from the printed output of predicted WT values.

In all of the figures, the effects of TDN and its interacting variables on WT level are shown for the time period from TDN = 110 (Apr. 20) to TDN = 250 (Sept. 17). This was done because of the obvious distortion in the relationships early and late in the year due to intercorrelations or joint effects among time of year, climatic variables of ANP and EV, and BPW. These variables may be independent of each other in a limited range of their values but not over the entire range. Certain combinations of the variables thus are outside the range of occurrence; if values are predicted for an unrealistic variable combination, they may be distorted (Salih, 1980).

The presence of intercorrelation and joint effects does not negate the use of multiple regression to develop prediction equations. Interrelationships among 2 or 3 variables may be studied at fixed levels of the others over their relevant ranges. However, one must always interpret these relationships with caution recognizing that the relationships in part of the range may be distorted to a varying degree. If joint effects are present, the prediction equation can predict realistic WT levels for various times of the year (TDN) if associated mean or typical values of the other variables are also varied in the equation.

<u>SL</u> In the upper half of the traverse (Clarion, Nicollet and Webster), SL had a quadratic effect on WT level modified by interactions with the quadratic function of TDN (Table 19). In the lower half of the traverse, with little range in SL, the SL variable had primarily a linear effect on WT; the TDN*SL interaction, significant at the 25% level, was not deleted because of an oversight.

The effects of SL on WT level in the upper half of the traverse at TDN levels from 110 to 260 are illustrated in Figure 21. The other variables were held constant at ANP = 9 cm, BPW = 1.0 cm, DB = 15, and EV = 3.7. The WT level increased initially as SL increased, reached a maximum at about 2.5 to 3% slope, and then decreased farther upslope in the traverse. The relationships between WT and SL were similar at all times shown; the curvature and SL values associated with maximum WT varied little within the TDN range illustrated although the interactions between SL and TDN were highly significant. Early and late in the year

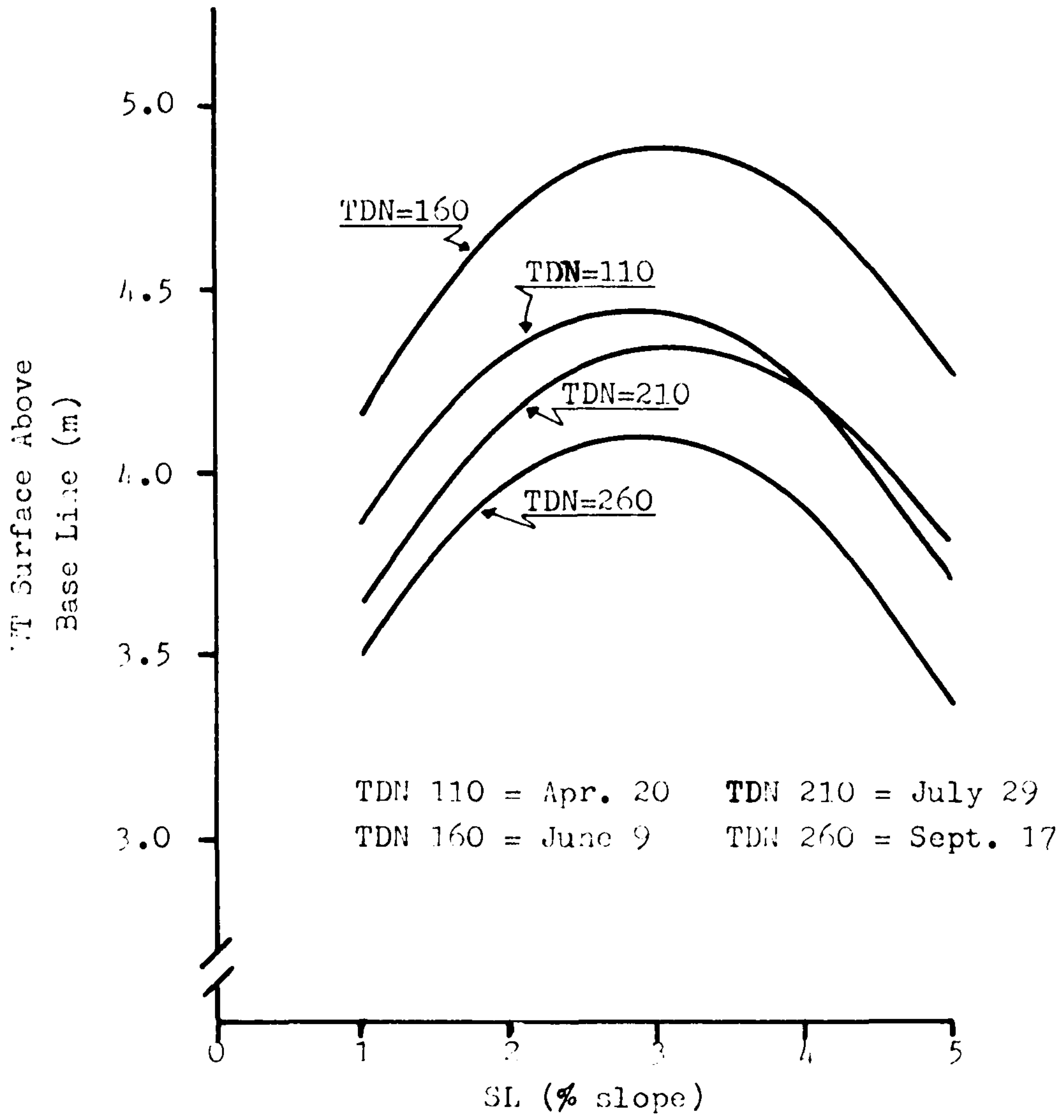


Figure 21. Predicted effects of SL on WT in the upper half of the undrained traverse at TDN levels of 110, 160, 210, and 260

these interaction effects were more obvious but probably not very meaningful because fixed levels of most other variables were too high for those times of the year.

The average WT level above the base line was higher in the Clarion soil in the drained traverse (Figure 13) but this effect was not apparent in the original data for the undrained traverse (Figure 20). From the soil surface, the WT level still was deeper in the Clarion than in the other soils.

<u>BPW</u> The BPW variable had a quadratic effect on WT level modified by a L*L interaction with TDN in the upper half and a linear effect modified by interactions with EV, TDN, and TDN^2 in the lower half of the traverse (Table 19). It had only a quadratic effect on WT in the regression for all soils combined in the undrained traverse (Table 16).

The effects of BPW on WT level in both halves of the traverse are shown in Figure 22. Only the effects from TDN = 110 to TDN = 210 are plotted because only one BPW value greater than 0 occurred after July 29 in all 3 years. The other variables were held constant at ANP = 9 cm, DB = 15 days, EV = 3.7 cm, and SL = 2 and 0% in the upper and lower halves, respectively. In the upper half, increasing BPW increased WT level curvilinearly in the spring but decreased it after late June. The variations in the initial slopes of the response curves and BPW levels associated with maximum WT level reflected the TDN*BPW interaction. In the lower half of the traverse, increasing BPW had little effect on WT at the selected TDN levels and at the fixed levels of the other variables.

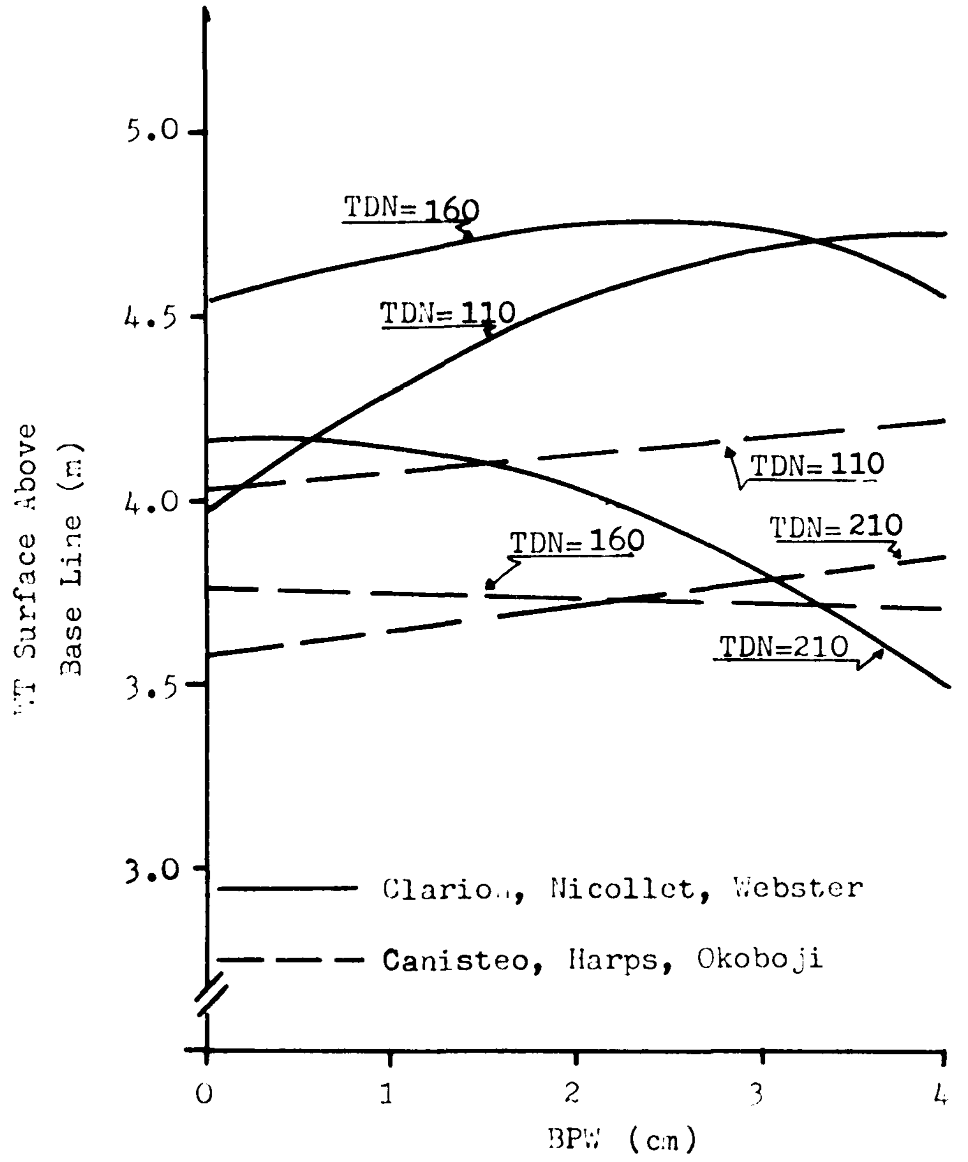


Figure 22. Predicted effects of BPW on WT in the upper and lower half of the undrained traverse at TDN levels of 110, 160, 210, and 260

In both halves of the traverse, the effects of BPW were in the same direction early in the season (at TDN = 110 or Apr. 20) but these effects tended to be in opposite directions by midsummer (Figure 22). This indicated that the net percolating water which moved below 1.5 m in the upper slope moved laterally and accumulated in the soils of the lower half as a higher WT level.

The BPW variable was based on the net water which had moved beyond the 1.5 m depth in a Nicollet loam at the Agronomy and Agricultural Research Center; net percolating water may have varied considerably in this undrained Clarion toposequence. More intercorrelation may have existed between BPW and the other variables than was shown by the simple correlations. Increased BPW results from greater ANP, less EV, or a combination of the two conditions; both variables were held constant in the prediction equation used to estimate the WT -- BPW relationships shown in Figure 22.

<u>ANP</u> Antecedent precipitation (ANP) had a linear effect on WT level in both halves of the traverse modified by the L*L interaction with TDN in the upper half and all three interactions with TDN in the lower half (Table 19). These effects are shown in Figure 23. The other variables were held at constant levels of BPW = 1.0 cm, DB = 15 days, EV = 3.7 cm, and SL = 2 and 0% in the upper and lower halves, respectively.

In the upper half of the traverse, ANP had a strong positive effect on WT level in the spring; this effect decreased linearly with time until it became negative in mid-August. The ANP effect in the lower half showed similar trends except that its effect varied curvilinearly with

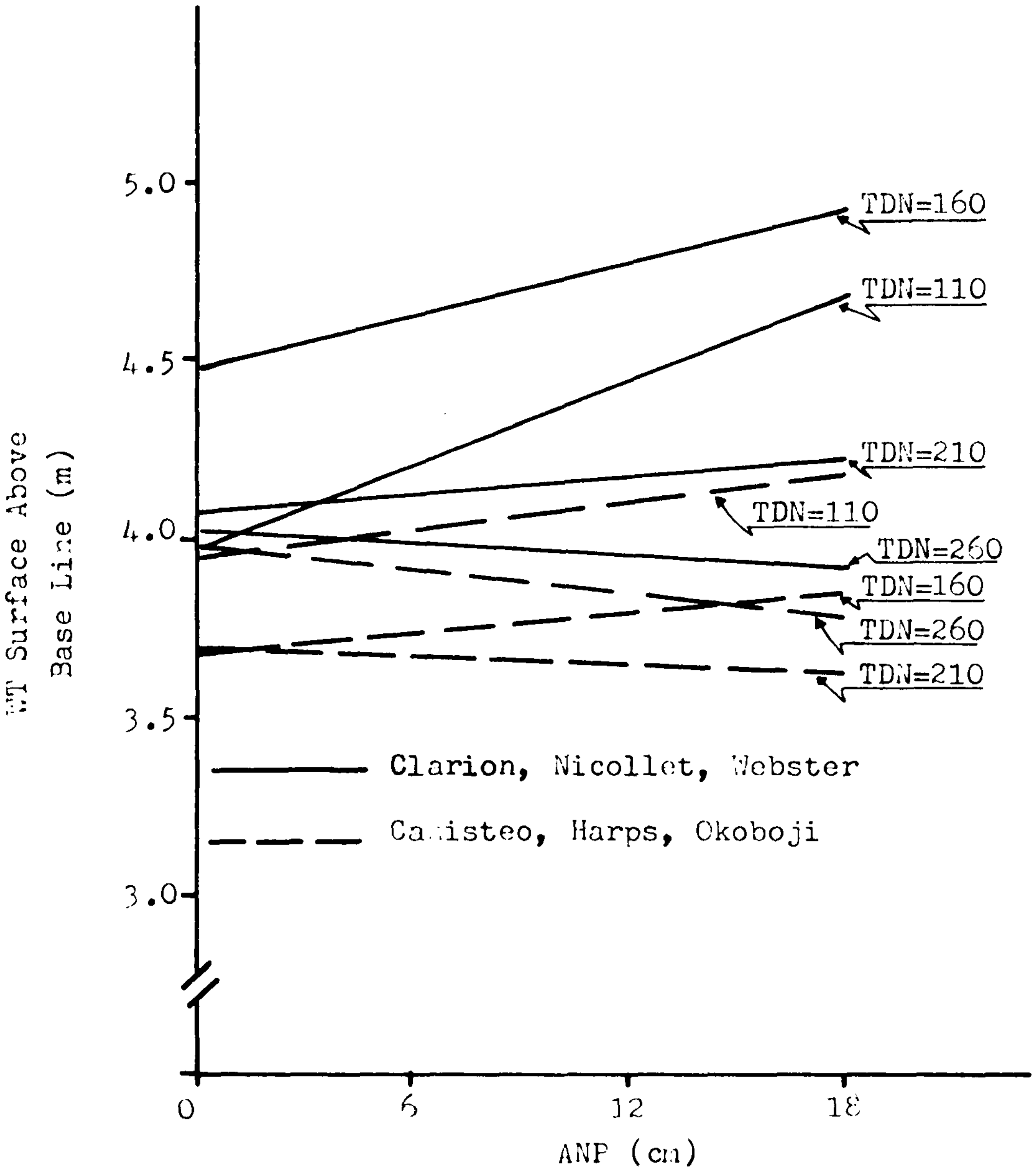


Figure 23. Predicted effects of ANP on WT in the upper and lower half of the undrained traverse at TDN levels of 110, 160, 210, and 260

time and became negative in mid-July. The effects of the higher-order interactions between ANP and TDN on WT in the lower half of the traverse were not very apparent in Figure 23. The positive effect of ANP on WT into July was expected. The negative effect later in the season, however, was not expected. Little effect was expected because all or most of the ANP replenishes the water removed by the crop in the July - September period and little moves out of the 1.5 m root zone.

If summer rainfall is much above normal, increased ANP should raise the water table.

EV Evapotranspiration (EV) had a linear effect on WT level in the upper half and a slight quadratic effect in the lower half of the traverse; both were modified by interactions with TDN (Table 19). These effects are shown in Figure 24. Other variables were constant at ANP = 9 cm, BPW = 1.0 cm, DB = 15 days, and SL = 2 and 0% in the upper and lower halves, respectively.

The effects of EV on WT were more variable in the upper than in the lower half of the traverse. Except in about the mid-May to mid-June period, increasing EV had a negative effect on WT level in the upper half of the traverse. In the lower half of the traverse, EV had a positive effect on WT level from mid-April to mid-May and a slight negative trend thereafter. The interactions between EV and TDN on WT level were due to the unexpected positive effects of EV on WT in the spring.

Since no crop was planted in the Okoboji and Harps area of the undrained traverse, the EV values for this site were unrealistic because transpiration was low relative to evaporation in the summer months.

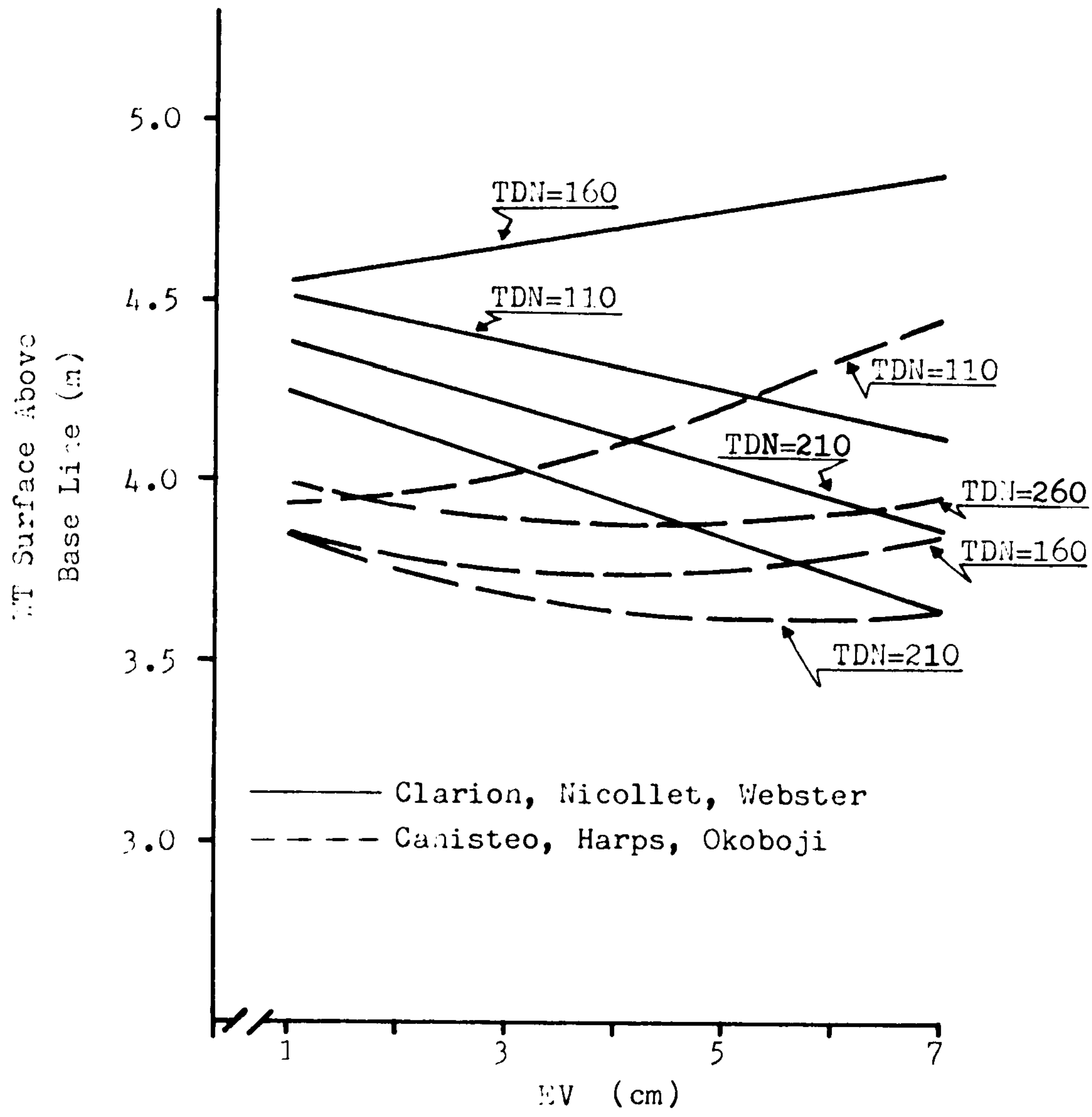


Figure 24. Predicted effects of EV on WT in the upper and lower half of the undrained traverse at TDN levels of 110, 160, 210, and 260

This may have affected the relationship in the lower traverse.

DB The DB variable (days between WT measurements) had linear or quadratic effects on WT level modified by L*L interactions with TDN in both halves of the traverse (Table 19). Its effect on WT levels will not be shown. Its behavior in the prediction models was unexpected, as was discussed in the DB subsection of the drained traverse section. The DB effect on WT appeared to be confounded with years (weather variables) and may be accounting for part of the effect of the weather variables on WT levels in the models.

TDN The effects of the time of year (TDN) variable were of most interest for predicting magnitude and duration of the water table in the soils of the Clarion toposequences. The effects of the other variables and their interactions with TDN were shown in Figures 21 through 24. These same interactions can be illustrated by plotting WT level on TDN at various levels of another variable, holding all other variables constant.

The effect of TDN on WT level, however, is more complex than can be shown in a figure. In both halves of the traverse, its curvilinear (cubic) effect on WT level was modified by linear*linear interactions with 2 or 3 variables, and by a cubic*linear interaction with 1 variable (Table 19). Thus, the relationship between WT level, TDN, and another variable, shown in the figures, will vary to some degree if the levels of the other variables held constant are changed. These variations, however, will not be large because no strong interactions between the other variables occurred in these regression models.

The factor causing most variation in the relationships was the intercorrelations among TDN and the other variables, as discussed previously. These effects on predicted WT levels were particularly accentuated early and late in the year because the levels of the variables held constant were average levels during the period of April through September. For this reason, the relationships between WT and TDN are shown from TDN = 110 (April 20) to TDN = 260 (Sept. 17).

The predicted WT levels above the base line from TDN = 110 to 260 (Apr. 20 to Sept. 17) at selected levels of SL, BPW, ANP, and EV are shown in Figures 25 to 28, respectively. For the predicted values, the variables were held at the following constant values: SL = 2 and 0% for the upper and lower half, respectively, of the traverse, and BPW = 1.0 cm, ANP = 9 cm, EV = 3.7 cm, and DB = 15 days for both halves of the traverse.

As shown in all figures, the WT level varied curvilinearly in a cubic fashion with time of year in the upper half and in a quadratic fashion with the selected time period in the lower half of the traverse. In the upper half, maximum WT levels occurred between TDN = 130 to 155 (May 10 to June 5) and the minimum WT levels occurred between TDN = 235 to 265 (Aug. 23 to Sept. 22), depending on the levels of the other variables with which TDN had interactions. In the lower half of the traverse, WT level decreased from TDN = 110 (Apr. 20) to a minimum which occurred from TDN = 175 to 235 (June 24 to Aug. 23) because of the interactions involving TDN. The contrasting changes in WT levels with time between the two halves of the traverse (Figures 25 through 28) show why the regression model combining all soils in the undrained traverse

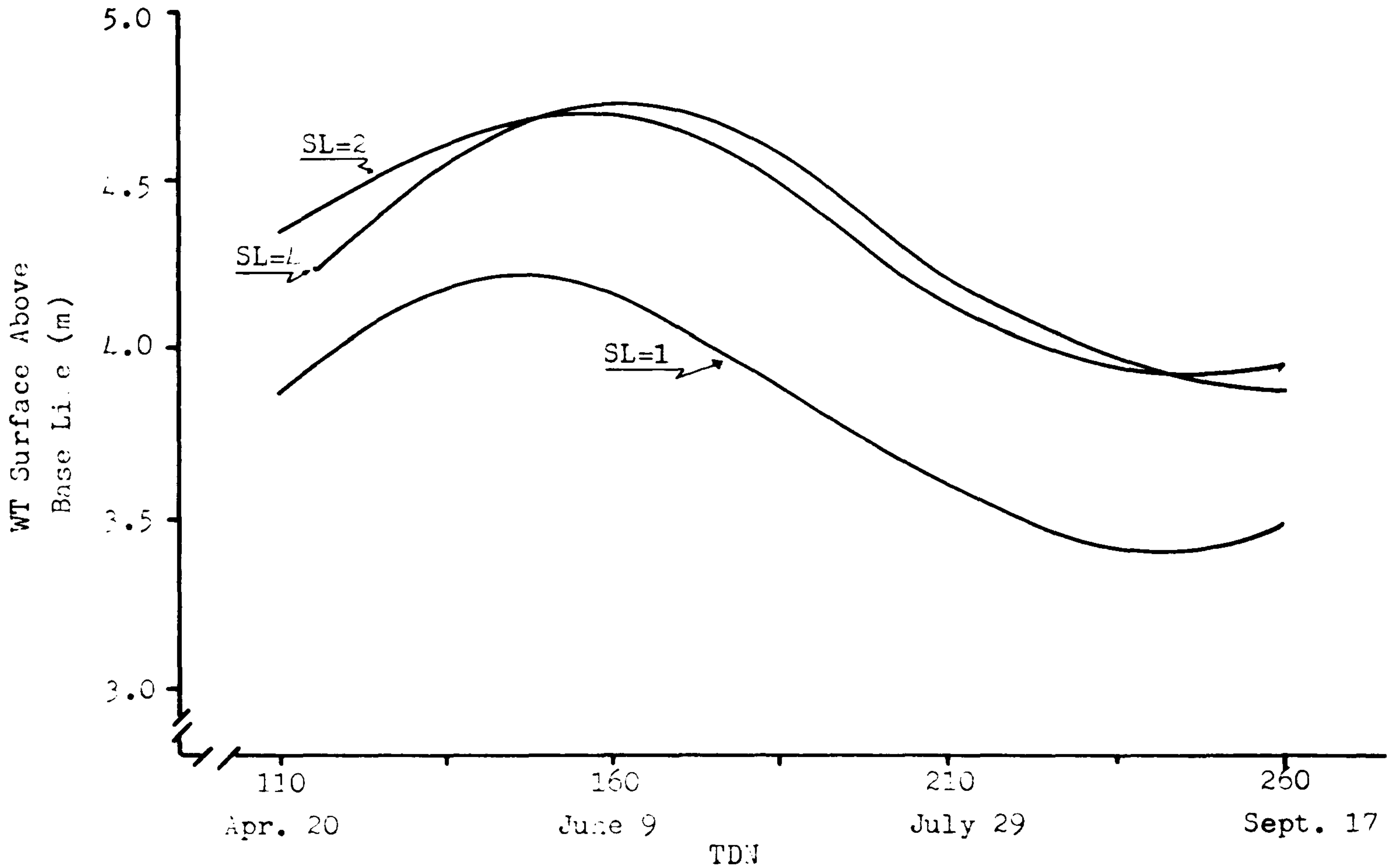


Figure 25. Predicted WT levels above a base line from TDN 110 to 260 at SL levels of 1%, 2%, and 4%, for upper half of undrained traverse

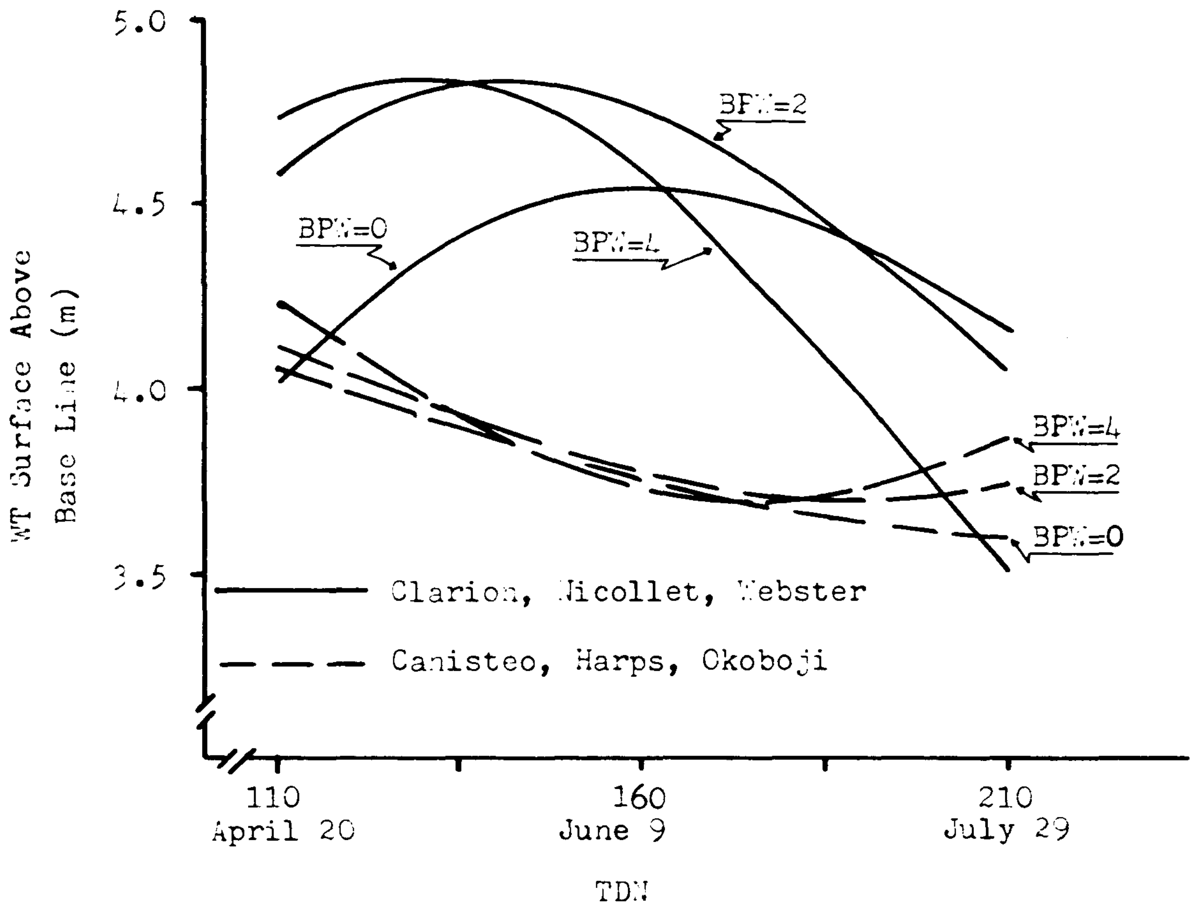


Figure 26. Predicted WT levels above a base line from TDN 110 to 260 at BPW levels of 0, 2, and 4 cm for upper and lower half of undrained traverse

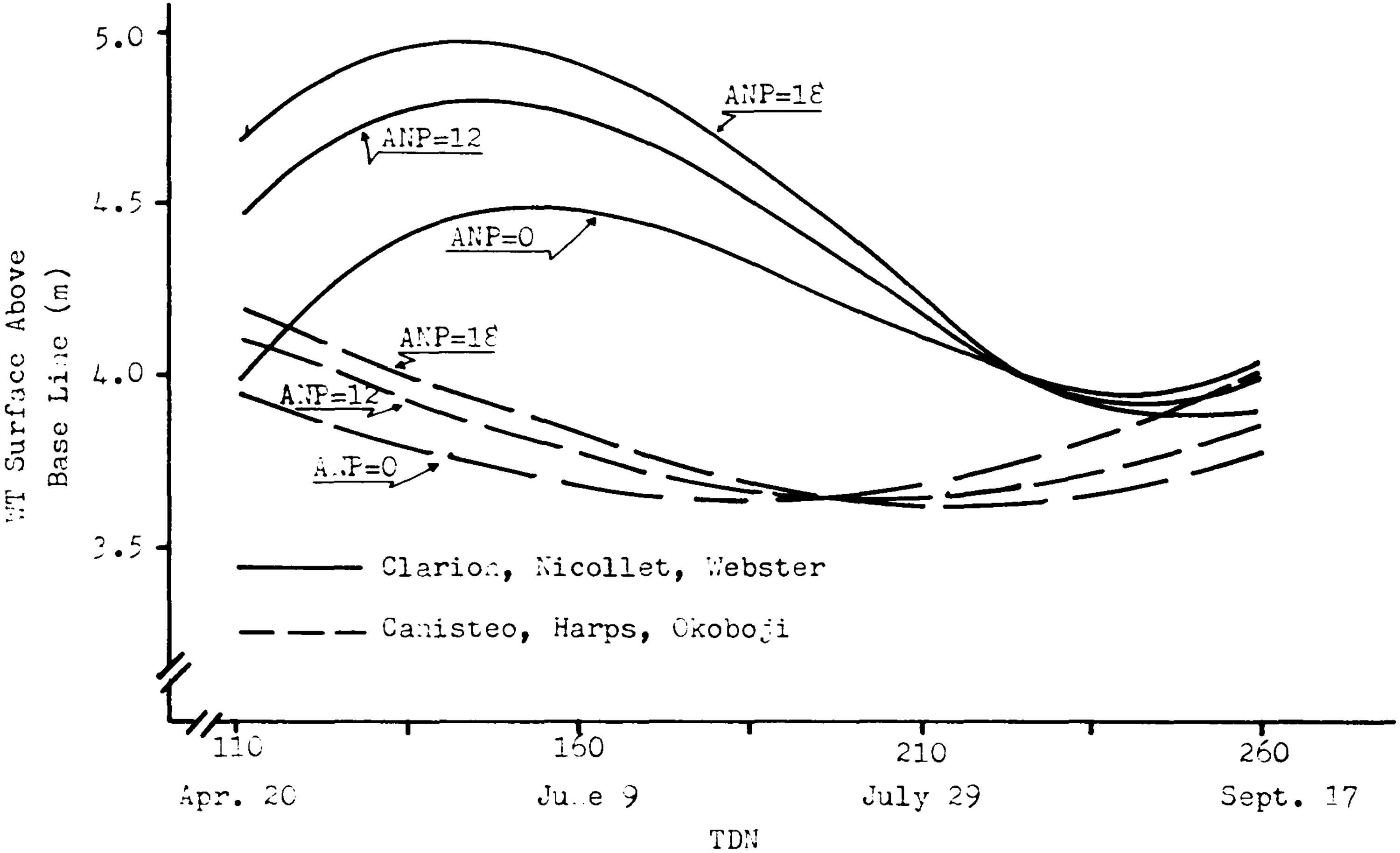


Figure 27. Predicted WT levels above a base line from TDN 110 to 260 at ANP levels of 0, 12, and 18 cm for upper and lower half of undrained traverse

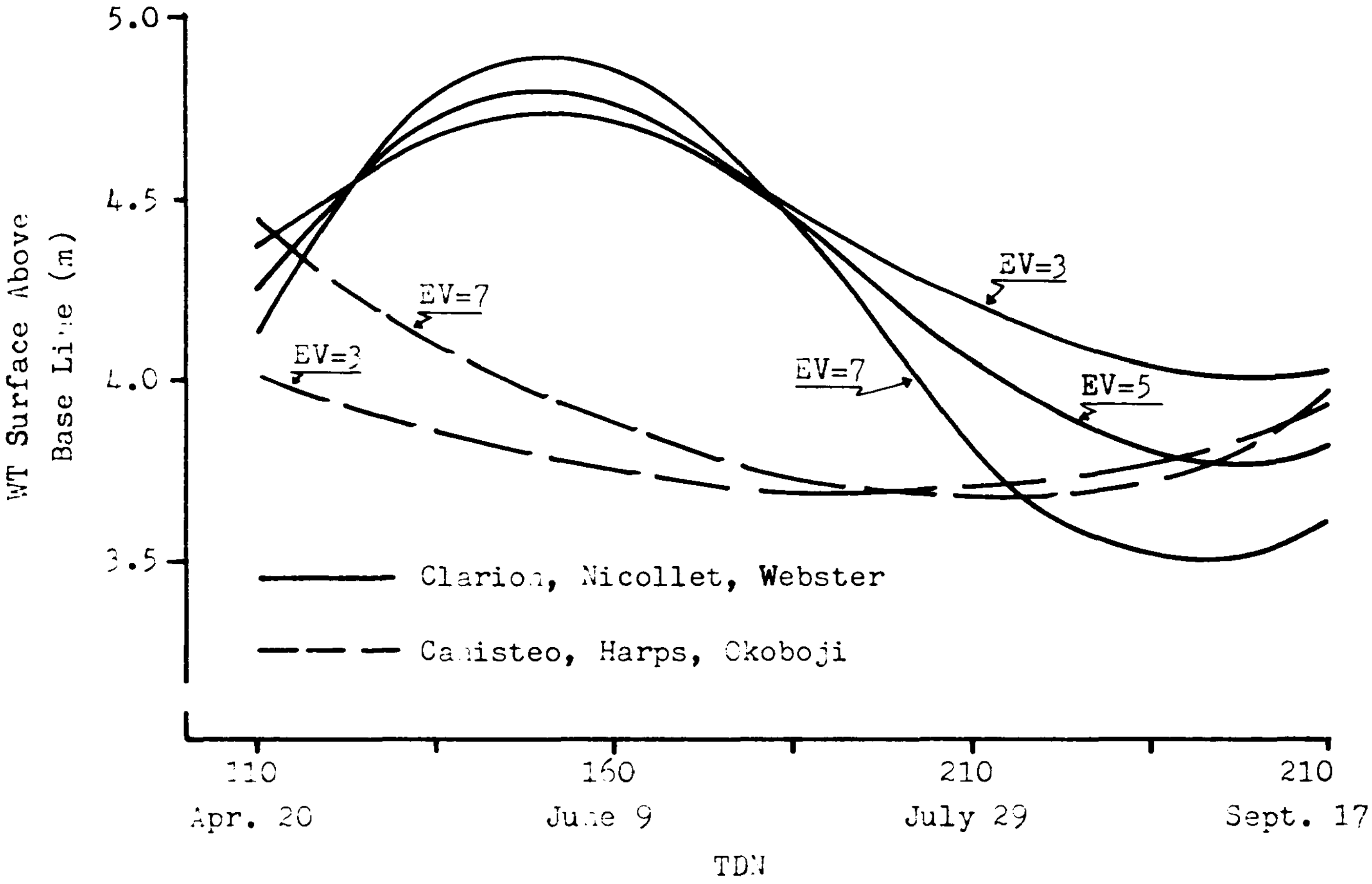


Figure 28. Predicted WT levels above a base line from TDN 110 to 260 at EV levels of 3, 5, and 7 cm for upper and lower half of undrained traverse

had such a low R^2.

To combine all soils in the undrained traverse into one prediction model would have required additional interaction variates to account for the contrasting changes in WT levels with time in the two halves of the traverse.

The effects of increasing SL on the curvilinear changes in WT level above the base line between April 20 and September 17 in the upper traverse are shown in Figure 25. Maximum and minimum WT levels occurred about May 30 and September 7, respectively, at the fixed levels used for the other variables. The WT level throughout the time shown increased to a maximum as SL increased from 1 to about 3% and then decreased as SL increased to 5%, reflecting the quadratic effect of SL on WT level. At the Clarion site (4% slope), the maximum and minimum WT levels were 4.8 and 3.9 m, respectively. Since the surface of the Clarion site was 6.1 m above the base line, the predicted WT level for the given conditions thus varied from 1.3 to 2.2 m below the soil surface. The surface of the Webster site (1% slope) was 4.8 m above the base line. The predicted maximum and minimum WT levels of 4.2 and 3.4 thus were 0.6 and 1.4 m below the soil surface.

The effects of increasing SL on WT levels in the lower half of the traverse were not illustrated. The SL variable had a linear effect modified by a weak interaction with TDN (Table 19). The partial derivative of WT w.r.t. SL showed that the WT increased from 0.20 to 0.16 m per 1% change in slope as time changed from April 20 to September 17. Thus, the predicted WT level in Canisteo (1% slope) was 0.20 to 0.16 m higher than in Harps and Okoboji (0% slopes).

The effects of increasing BPW on water table fluctuations are shown in Figure 26 for both halves of the traverse. As explained previously, these effects are shown only for the April 20 to July 29 period. The WT level increased early in the season as BPW increased but then decreased with increasing BPW in June and July. This reversal of effect was more pronounced in the upper than in the lower half of the traverse. The effect of BPW on WT level early in the season cannot be explained, as was discussed previously.

The WT levels in both halves increased early in the season and until mid-July to mid-August as ANP increased (Figure 27). This was the expected effect. The reversal of the ANP effect on WT late in the summer was not expected. Little or no effect of ANP on WT level would be expected in late summer and early fall until the subsoil moisture depleted by the crops is replenished. After the root zone is filled to field capacity, excess moisture than would raise the water level.

The effects of increasing EV on water table fluctuations are shown in Figure 28 for both halves of the traverse. In the lower half of the traverse, the WT level at EV = 5 was not shown in the figure; it occurred about half way between those for EV = 3 and 7. Except in about the mid-May to mid-June period, the water table decreased as EV increased in the upper half. In the lower half, EV had a positive effect early in the season and little effect thereafter. The positive effects of EV on WT levels early in the season were unexpected.

Weather variables in study years compared to long-term means

A comparison between mean monthly temperatures from 11-1-77 to 10-31-80 and the 30-year means from 1941 to 1970 (Harmon and Duncan, 1978) showed close agreement (Figure 29). A comparison of mean monthly precipitation (Figure 30) for these same time periods showed disagreement.

Water table studies should be carried out over long periods of time. Thompson (1969) reported that irregular cyclical weather is common and that alternate decades of wet and dry are common. For example, the teens, '30s and '50s, were decades of warm, dry summers, while the '20s, '40s, and '60s, were decades with cooler temperatures and more precipitation. This cyclic pattern suggests that water table studies should be conducted over a 20 year period or at least long enough to include the extremes in precipitation and temperature.

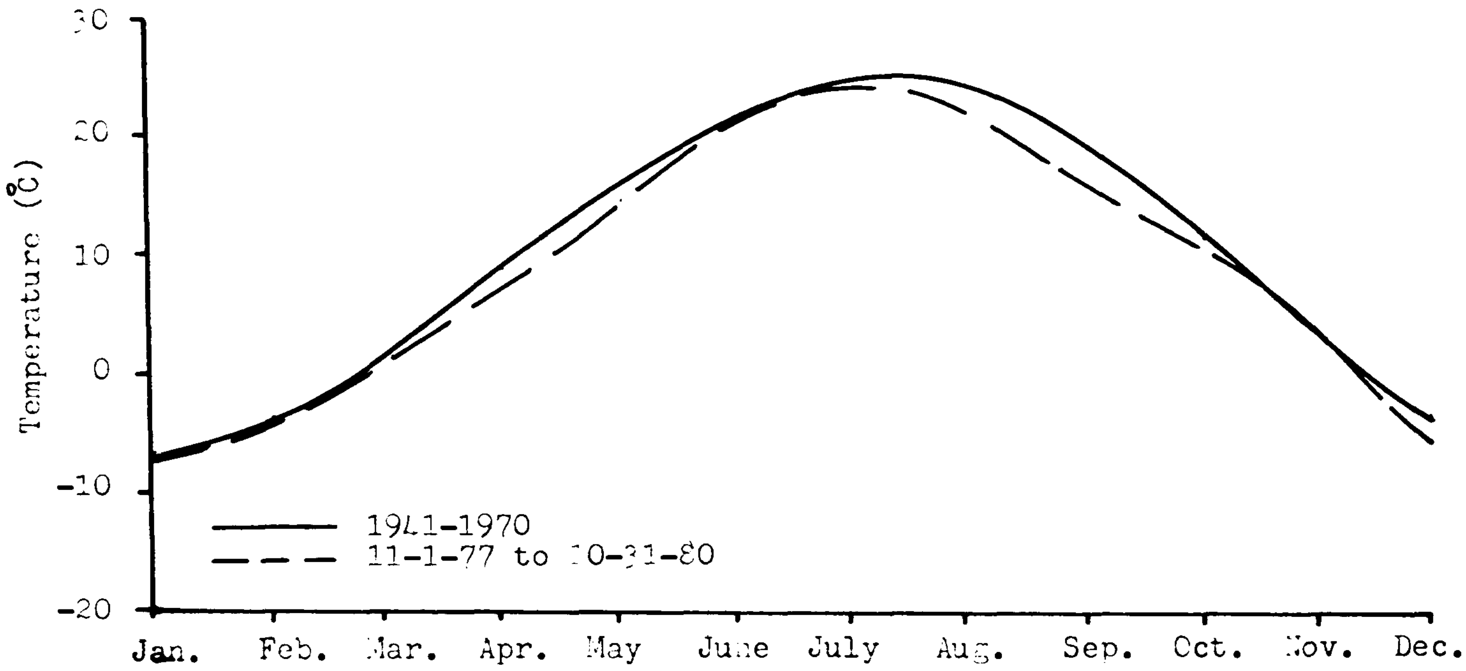


Figure 29. Monthly temperatures for the study area

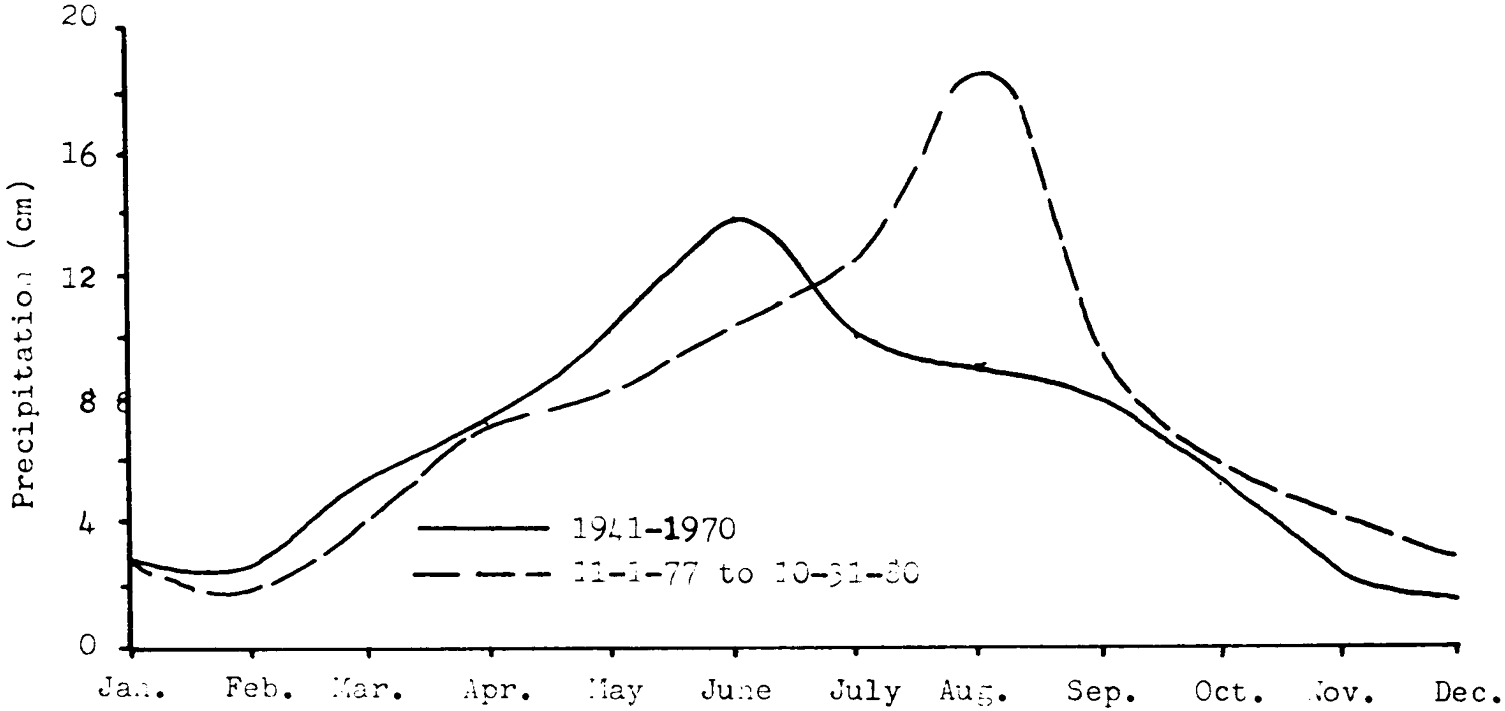


Figure 30. Precipitation by month for the study area

SUMMARY AND CONCLUSIONS

Several soil series comprising the Clarion toposequence have periodic high water tables. The ability to accurately predict depth and duration of water tables is important for making wise agricultural and non-agricultural use decisions. Little is known about the quantitative relationship of water tables within and between individual members of the Clarion toposequence. A better understanding of variables related to water table depth and duration is invaluable for land use management. Knowledge of water table fluctuations also enhances explanation of genetic pathways among and between members of the Clarion toposequence.

Subsequent to settlement, much of the Des Moines glacial lobe had been artificially drained. The effect of artificial drainage on depth and duration of water tables for several members of the Clarion toposequence has not been documented.

Previous work by Nelson et al. (1973) in North Carolina showed that depth and duration of water tables could be predicted for soils in a non continuous function by means of multiple linear regression models. It appeared that multiple linear or curvilinear regression models could be developed for a continuous function to predict depth and duration of water tables at any position along a Clarion toposequence traverse.

The objectives of Part I were as follows:

1. To investigate water table relationship along undrained and artificially tile drained traverses for members of the Clarion toposequence and to develop mathematical water table

prediction equations for each site and each traverse, and

2. To interpret variable effects on depth and duration of water tables for each site and each traverse.

One representative artificially tile drained and one undrained Clarion toposequence were selected in Story County, Iowa. In order to determine watershed boundaries, a topographic map of each area was constructed. Detailed soil survey maps of these watersheds were also made.

Perforated plastic tubes were inserted into each most representative soil series site within each traverse. The soil series sites selected were within the range of respective National Cooperative Soil Survey USDA, SCS model profile description requirements. These plastic tubes were used as water table observation wells for the duration of the study.

Water table levels were measured and recorded at each observation well approximately weekly from November 1, 1977, through October 31, 1978, biweekly from November 1, 1978, through October 31, 1979, and monthly from November 1, 1979, through October 31, 1980. A battery-powered drop line meter was used to measure water table levels.

Regression equation variables for individual sites were as follows:

1. Antecedent precipitation (ANP) was defined as the amount of precipitation received at the site during a 30 day period prior to the date of water table (WT) measurement.
2. Cumulative precipitation (CP) was defined as the amount of precipitation received at the site between water table (WT) measurements. Both antecedent and cumulative precipitation for 11-1-77 through 10-31-80 were calculated from weather

records of the Ames Pollution Control Center, Ames, Iowa.

3. Evapotranspiration (EV) was defined as the amount of evaporation either from the soil surface, through plant leaves, or both, that occurred from 1 to 30 days prior to the date of water table (WT) measurements.

4. Net percolating water (BPW) was defined as the amount of water percolating below a 152 cm depth.

   Evapotranspiration (EV) and net percolating water (BPW) were calculated by a computer program estimating soil moisture under corn. These values were calculated from data collected on a Nicollet soil series site at the Agronomy and Agriculture Engineering Research Center located west of Ames along U.S. Highway 30.

5. Time (TDN) was defined as the day of the month and year of water table (WT) measurement.

6. Days between water table readings (DB) was defined as the number of days between water table (WT) measurements.

7. Water table (WT) was defined as the distance to the water table (WT) surface from the soil surface. These values were transformed to distances above a base line.

Regression equation variables for traverses in addition to those variables already mentioned for the individual sites were as follows:

1. Distance from edge of watershed to the individual site (SD).
2. Percent slope at each site (SL).

The study of water table fluctuations involved variables that occur naturally and, as such, they can not be controlled. Thus, these variables were considered simultaneously. In order to study the effect of one variable or a group of variables on water table levels, multiple regression techniques were employed.

The initial regression models for water table level (WT) included the cubic function of time (TDN), quadratic functions of the other variables, all possible linear*linear interactions between variables, and the quadratic*linear and cubic*linear interactions between TDN and all other variables. Selection of final models was by stepwise, backward elimination of nonsignificant variates using the PROC GLM procedure.

Two major differences were noted in overall water table depth and duration between artificially drained and undrained traverses. First, a plot of mean monthly WT showed the water table surface was flat from Okoboji to Clarion in the undrained traverse. A plot of mean monthly WT showed a slight rise from Okoboji to Clarion in the drained traverse. The tile drain was apparently removing water faster from lower areas than the water could move laterally from farther up slope. Second, the water table surface was closer to the soil surface in the undrained traverse than in the artificially drained traverse. Generally, for any point on the undrained traverse, the water table surface was 70 cm closer to the soil surface than at a comparable position on the artificially drained traverse.

Multiple Regression Analyses for Individual Soil Sites in Drained and Undrained Traverses

Simple linear correlation coefficients showed that only a few correlations were greater than $r = \pm 0.40$. Correlations between antecedent precipitation (ANP) and cumulative precipitation (CP) for soils in both drained and undrained traverses were $> \pm 0.74$. Therefore, a procedure was used to determine which of these variables should be retained. The CP variable was deleted from all subsequent models.

Artificially tile drained traverse - individual soil sites

Final models for the artificially drained traverse showed that the mix of variates retained in the final regression models varied widely among soils. Significance levels of the retained variates also varied widely. The final model for Clarion had the most significant variates while those for Canisteo and Harps had the least.

Time (TDN) had a cubic effect on WT level in all except the Nicollet soil, but this effect was strong in the Clarion soil and weak in the Canisteo and Harps soils. The cubic effect of TDN was expressed primarily through its higher order interactions with one or more of the other variables.

The effect of antecedent precipitation (ANP) on WT level was variable. It had a large effect through its interactions in the Clarion, Nicollet, and Okoboji soils, a large quadratic effect without interaction in the Webster soil, and little effect in the Canisteo and Harps soils.

Evapotranspiration (EV) had a strong effect on WT, either through its quadratic function or interactions with TDN, in all soils except Canisteo and Harps. Percolating water below 1.5 m (BPW) had some effect on WT level in the Clarion, Webster, and Okoboji soils, very little effect in Nicollet, and none in Canisteo and Harps. Days between sampling (DB) which was included to account for different sampling times in the 3 years, had some effect on WT in all soils except Okoboji.

Undrained traverse - individual soil sites

Final models for the undrained traverse showed that variates differed among soils. Significance levels of the variates also differed. The linear and quadratic effects of the variables had greater significance in the models for the undrained soils than for the drained soils.

Time (TDN) had a strong cubic effect on WT level modified by interactions in the Nicollet and Webster soils, a weak cubic effect in the Clarion, Harps, and Okoboji soils, and only a quadratic effect with little interaction in the Canisteo soil.

Antecedent precipitation (ANP) had no effect to slight effect on WT in the Clarion and Harps soils, a linear effect plus an interaction effect in Canisteo, and a greater effect on WT in the other soils. EV had linear or quadratic effects on WT modified by interactions with TDN in all soils except Canisteo in which it had only a linear effect on WT level. BPW had primarily a linear or quadratic effect on WT in the Clarion, Canisteo, Harps, and Okoboji soils but was involved in highly significant but variable effects on WT in all soils.

All variables had varying effects on WT levels in most undrained soils.

Multiple Regression Analyses for All Soils Within Each Traverse

Two variables included in addition to those already mentioned for individual sites were distance from the top of the watershed to the soil site (SD) and percent slope at the soil site (SL). Correlation analyses showed that ANP and CP and SL and SD had simple correlations $r > \pm 0.70$. Therefore, a procedure was used to determine which of these variables should be retained. ANP and SL gave higher R^2 values in the alternate models and were retained.

The initial regression models for water table level (WT) included the cubic function of time (TDN), quadratic functions of the other variables, all possible linear*linear interactions between variables, and the quadratic*linear and cubic*linear interactions between TDN and all other variables.

The R^2 of the final prediction model for the artificially drained traverse was 0.73. Slope (SL) had a linear effect on WT level modified by strong interactions with TDN and DB. The partial derivative of WT with respect to (w.r.t.) SL showed that the linear slope of the WT response to the SL variable varied curvilinearly (in a quadratic way) with increasing TDN.

Net percolating water below 1.5 m (BPW) had a negative linear effect on WT level. Antecedent precipitation (ANP) had a weak effect on WT level primarily through its interactions with TDN. The partial derivative of WT w.r.t. ANP showed that TDN of May 21 was associated with the maximum slope of linear WT response to ANP.

Evapotranspiration (EV) had a quadratic effect on WT level modified by strong interactions with TDN. The effect of EV on WT level was in the expected direction most of the year, but joint effects of EV and other variables distorted some of these relationships. Days between WT measurements (DB) had a linear effect on WT level modified by strong interactions with TDN and SL.

Time (TDN) had a quadratic effect on WT level modified by strong interactions with SL, DB, and EV and weak interactions with ANP. The partial derivative of WT w.r.t. TDN showed that the slope of the change in WT level per unit (days) of TDN varied with the levels of the TDN, SL, ANP, DB, and EV variables.

The R^2 of the final prediction model for the undrained traverse was 0.44. This R^2 was much lower than that for the undrained traverse. The final model for the undrained traverse had more significant variates. Slope (SL) had a quadratic effect on WT modified by an interaction with DB and weak interactions with TDN. Percolating water below 1.5 meters (BPW) had only a quadratic effect on WT level. Antecedent precipitation (ANP) had a linear effect on WT level modified by strong interactions with all components of TDN. Evapotranspiration (EV) had a quadratic effect on WT level modified by strong interactions with the linear and quadratic components of TDN. Days between WT measurement (DB) had a quadratic effect on WT level modified by interactions with SL and linear component of TDN. Time (TDN) had a cubic effect on WT level modified by L*L interactions with SL, ANP, DB, and EV, Q*L interactions with SL, ANP, and EV, and C*L interactions with SL and ANP.

Multiple Regression Analyses for Undrained Traverse, Two Groups

To determine why the R^2 for the undrained prediction model was low, a stepwise procedure was used to combine soils sequentially. The R^2 values indicated that Clarion, Nicollet, and Webster (upper half of the traverse) comprised one group while Canisteo, Harps, and Okoboji (lower half of the traverse) comprised the other group. Separate regression models were developed for these two groups. The R^2 of the final prediction models for the upper and lower halves were 0.60 and 0.49, respectively.

The values for WT levels at selected combinations of TDN and each of the other variables with the others held constant were computed from the regression equations. The effects of TDN and its interacting variables on WT level were accurate only for a time period from TDN = 110 (Apr. 20) to TDN = 260 (Sept. 17). This was done because of the obvious distortion in the relationship early and late in the year due to intercorrelations or joint effects among time of year, climatic variables of ANP and EV, and BPW.

WT level varied curvilinearly in a cubic manner with time of the year in the upper half and in a quadratic manner with the selected time period in the lower half of the traverse.

Contrasting changes in WT levels with time between the two halves of the traverse showed that combining all soils in the undrained traverse resulted in low R^2 value. Additional variables must be included to account for the contrasting changes in WT levels with time in the two halves of the traverse.

PART II. DIFFERENCES IN DISTRIBUTION OF CLAY AND TOTAL PHOSPHORUS BETWEEN SOILS IN ARTIFICIAL TILE DRAINED AND UNDRAINED TRAVERSES

INTRODUCTION

It was concluded by Walker (1965) that differences in physical and chemical properties between soils occupying specific positions along a hillslope of a closed system were due to parent material and internal moisture conditions. For example, pockets of sand or concentrations of clay randomly dispersed throughout the Cary till caused differences. Hillslope erosion from 8,000 to 3,000 years B.P., and subsequent distribution of surficial sediments along the hillslope, in a somewhat systematic pattern, where the geometric mean of soil particles becomes progressively smaller from upslope to downslope positions also helps explain soil differences. A continuum of internal drainage from well to very poor along the hillslope, as determined by topography, was also important in determining differences between soils along the hillslope. Therefore, major differences between soils along a hillslope such as the Clarion toposequence were due to surficial erosion and deposition, internal drainage, and associated weathering.

Water percolating through the surficial sediment leaches soluble chemical weathering products both vertically and laterally. These chemical weathering and erosional products can not leave the system and accumulate in lower hillslope positions. For example, carbonates, iron, phosphorus, clay, and organic carbon in soils are significantly different because of differences in internal chemical weathering environments along the hillslope. Cleaves et al. (1970) in their study of an open watershed in the Piedmont of Maryland, concluded that lateral underground movement of soluble products of chemical weathering removed five times more weathering products than that attributed to mechanical erosion. On a long term basis, nearly one-half of the mineral weathering resulted from chemical solution. Walker (1965) also stated that lateral movement of mobile soil constituents modifies chemical weathering processes.

Water tables can play a major role in additions, removals, transfer, and transformation processes. For example, transformation and transfer of phosphorus is greatly influenced by water movement. Distribution of phosphorus can be used to aid the understanding of these soil forming processes. Even though phosphorus is considered as relatively immobile during short periods of time, a considerable amount of phosphorus can be translocated over long periods of time. Phosphorus eluviation and illuviation, either vertically or laterally, can be used to study water movement. The amount of phosphorus translocation and redeposition is also used as an indicator of soil development.

A soil system must be considered as dynamic in that it never achieves equilibrium. This is especially true for open systems where removal of weathering products is comparatively rapid and continuous. Conversely, in a closed system weathering products from higher hillslope soils accumulate in lower hillslope soils. Since these products can not leave the system, a rather rapid quasi-equilibrium is created. This is especially applicable for soils occupying lower hillslope positions. Kinds and rates of genetic processes for these lower hillslope soils are controlled by depth and duration of water tables.

Differences in depth and duration of water tables between soils occupying comparable hillslope positions for artificially tile drained and undrained traverses of Clarion toposequences were discussed in Part I. To estimate and relate genetic pathways to depth and duration of water tables for drained and undrained traverses, several physical and chemical properties were selected. Since the scope of this study can not include all chemical and physical properties involved in pedogenetic processes, only a few selected chemical and physical constituents were included.

Specific objectives of Part II of this study were:

1. To determine if there are differences in clay distribution for soils in the tile drained and undrained traverses,
2. To determine if there are differences in total phosphorus distribution for all soils in the tile drained and undrained traverses,
3. To determine if there are differences in organic carbon and organic phosphorus distribution for all soils in the tile drained and undrained traverses, and
4. To determine if there are differences in pH distribution for all soils in the tile drained and undrained traverses.

MATERIALS AND METHODS

Field Procedures

One representative artificially tile drained and one representative undrained Clarion toposequence were selected. Both toposequences were located in Story County, Iowa. Figures 1 and 4, Part I, show location of these toposequences.

Watershed boundary, soils map, topography map, and location of the Clarion toposequence within each watershed, are shown in Figures 5 and 6, Part I.

Each toposequence contained a representative Typic Hapludoll - Clarion, Aquic Hapludoll - Nicollet, Typic Haplaquoll - Webster, Calcic Haplaquoll - Canisteo, Typic Calciaquoll - Harps, and Cumulic Haplaquoll - Okoboji. Soil cores were collected at all sites in both traverses.

Soil profile cores, approximately 5 cm in diameter and 335 cm long, were collected with a Giddings hydraulic soil probe. All soil cores were wrapped in freezer paper and transported to the laboratory.

Laboratory Procedures

Soil profile descriptions

Soil cores were described in the laboratory as outlined by the Soil Survey Manual (Soil Survey Staff, 1951). Weathering zones were indicated by using terminology of Hallberg et al. (1978).

Subsequent to completion of soil profile descriptions, soil cores were allowed to air dry. Soil samples were then ground with a mortar and pestle to pass a 2mm sieve. Pebbles that were larger than 2mm and and would not pass the 2mm sieve after grinding were removed and weighed. A representative 20 gram subsample from each horizon was ground to pass a 100 mesh sieve. These finer ground samples were used to determine free iron, organic carbon, total phosphorus, and organic phosphorus content.

Particle size analysis

Particle size analysis as outlined by Kilmer and Alexander (1949) was used to determine total sand, coarse and fine silt and clay percents. Total sand was fractionated into very fine sand (62 - 125 microns), fine sand (125 - 250 microns), medium sand (250 - 500 microns), coarse sand (500 - 1000 microns), and very coarse sand (1000 - 2000 microns) with a Cenco-Meinzer Sieve Shaker (Central Scientific Company, Chicago, Illinois).

Soil pH

A 1:1 soil to water mixture was used to determine soil pH. The soil solution was mixed, remixed in 30 minutes, allowed to stand for 60 minutes and read with a Corning Combination Electrode and a Bechman Zeromatic pH Meter.

Organic carbon

Organic carbon determinations as described by Mebius (1960) were made on 0.2 to 0.4 gram soil samples. These soil samples were treated with potassium dichromate and concentrated sulfuric acid to oxidize organic carbon. After a few drops of indicator solution containing N-phenylanthronillic acid and sodium carbonate were added, the soil solution was titrated with a Mohr's salt solution.

Total phosphorus

Total phosphorus was determined using the method described by Dick and Tabatabai (1977). The amount of P in solution was determined by the intensity of a molybdenum blue color. Concentrations of P in solution were determined with a spectrophotometer.

Inorganic phosphorus

Inorganic phosphorus was determined as described by Legg and Black (1955). Inorganic phosphorus was extracted from 1 gram samples with concentrated hydrochloric acid. The amount of inorganic phosphorus in solution was proportional to the intensity of molybdenum blue color. Solution concentrations were read on a spectrophotometer.

Organic phosphorus

Organic phosphorus was determined by subtracting inorganic phosphorus from total phosphorus.

Free iron and iron oxide

Free iron was determined using the method described by Holmgren (1967). Sodium dithionite - sodium citrate was added to 100 mesh soil subsamples. Concentration of free iron was determined on a spectrophotometer. These concentrations were then expressed as percent free iron.

Iron oxide percent was calculated from percent free iron.

RESULTS AND DISCUSSION

Particle size distribution plots for soils in the tile drained traverse (Figures 31 to 36), and undrained traverse (Figures 37 to 42), showed vertical textural variations. These textural variations appeared to systematically extend across the hillslope from highest to lowest position. This observation was suggested by zones characterized by changes in percent sand, silt, or clay within short distances. Zones of changing texture also increased in thickness from highest to lowest hill-slope positions.

Plots showed particle size differences above 80 cm for Clarion (Figure 31) and above 130 cm for Okoboji (Figure 36) in the tile drained traverse. Likewise, textural changes were noted above 80 cm for Clarion (Figure 37) and above 130 cm for Okoboji (Figure 42) in the undrained traverse. This lack of uniformity was also present in zones above a projected plane from Clarion to Okoboji (fore-named depths) for Nicollet, Webster, Canisteo, and Harps in both the drained and undrained traverses.

These observations suggested a systematic system of erosion and deposition within the closed hillslope. A contact between surficial hillslope sediments and unaltered till was identified. The variables that were used to conclude this are as follows: (1) finer textured materials were found above the original till, (2) concentration of finer textured material with decreasing slope, and (3) increasing thickness of finer textured surficial sediment with decreasing slope. Both tile drained and undrained toposequence appeared to fit into the erosional

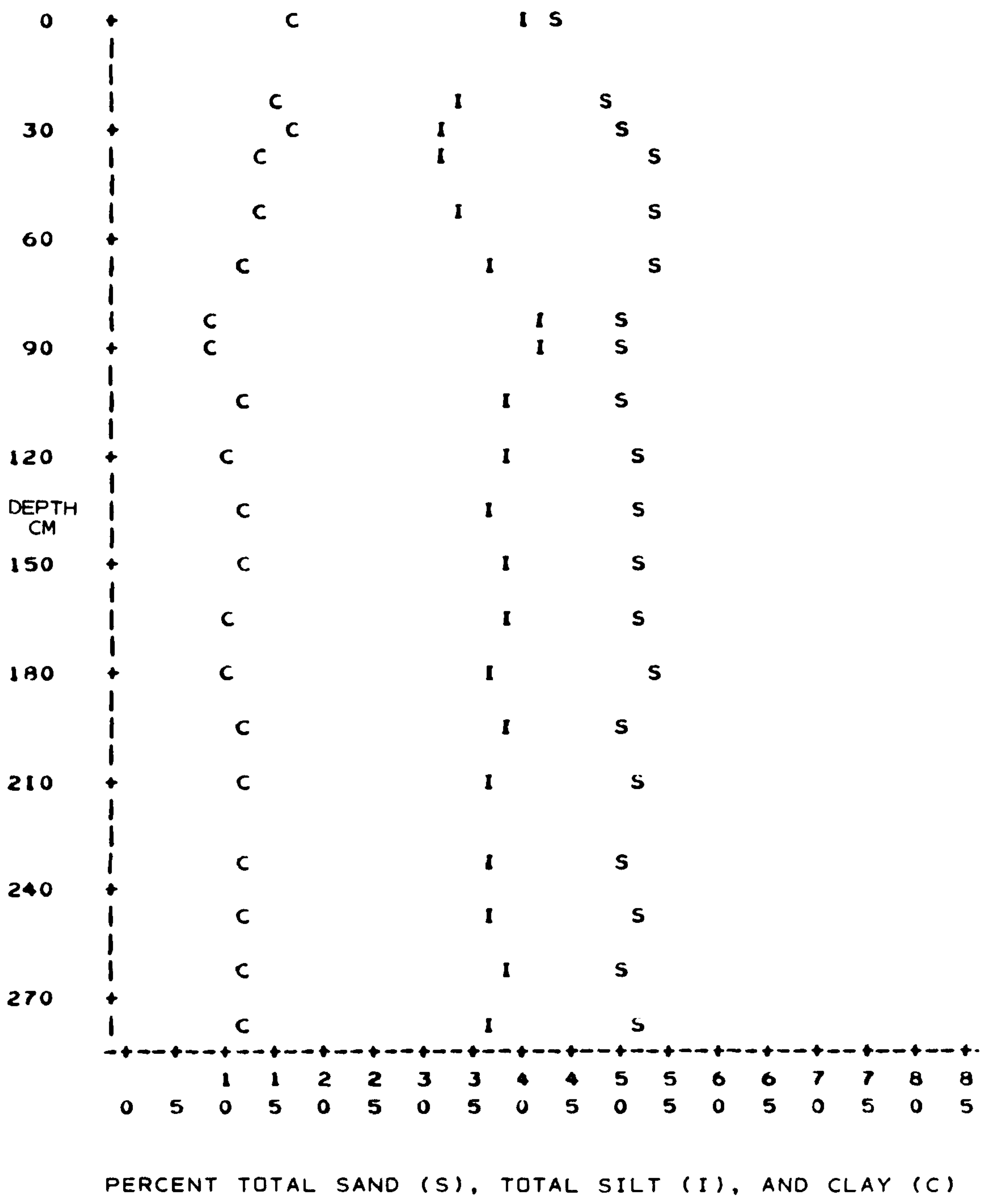


Figure 31. Distribution of sand, silt, and clay with depth for Clarion in tile drained traverse

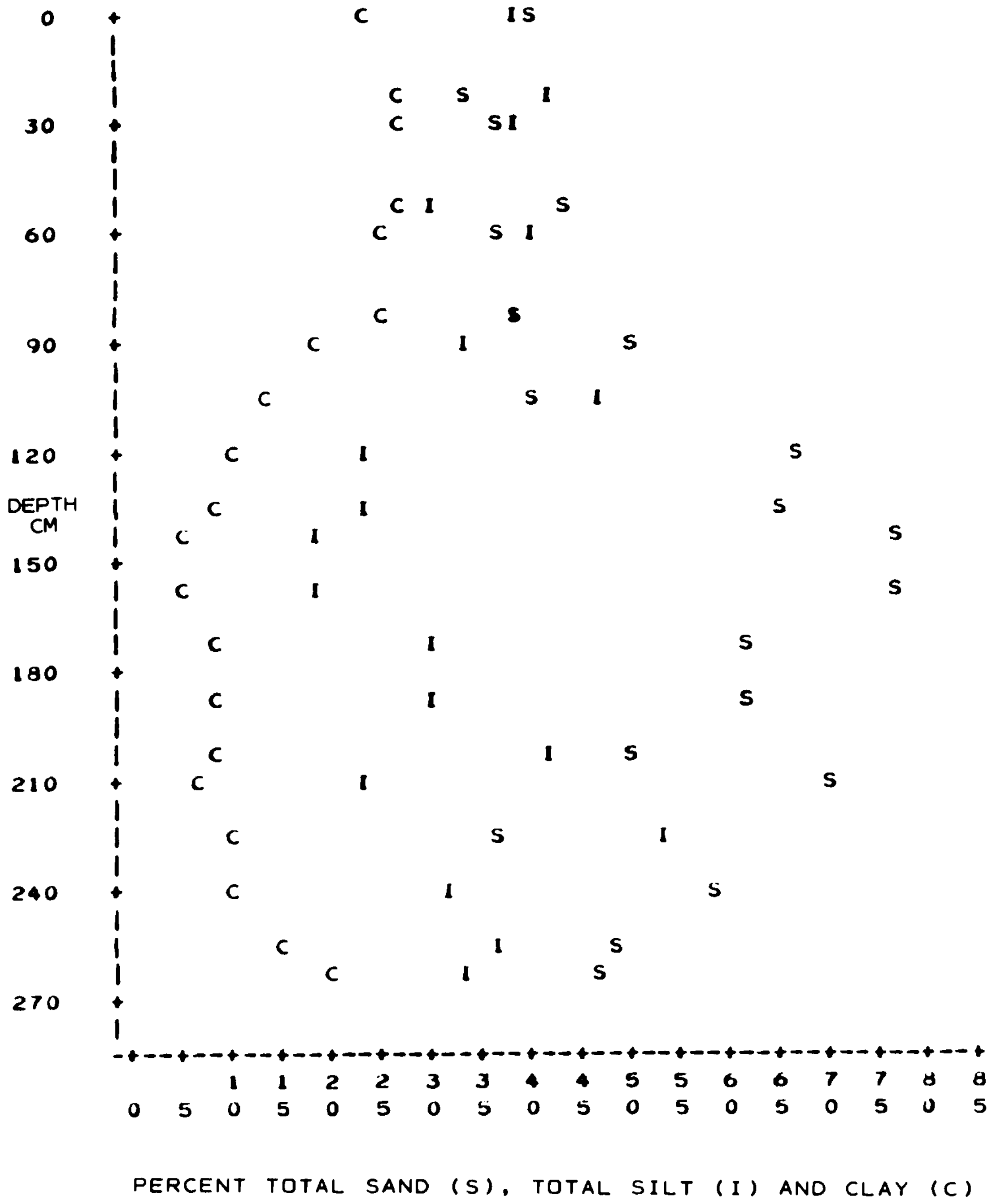


Figure 32. Distribution of sand, silt, and clay with depth for Nicollet in tile drained traverse

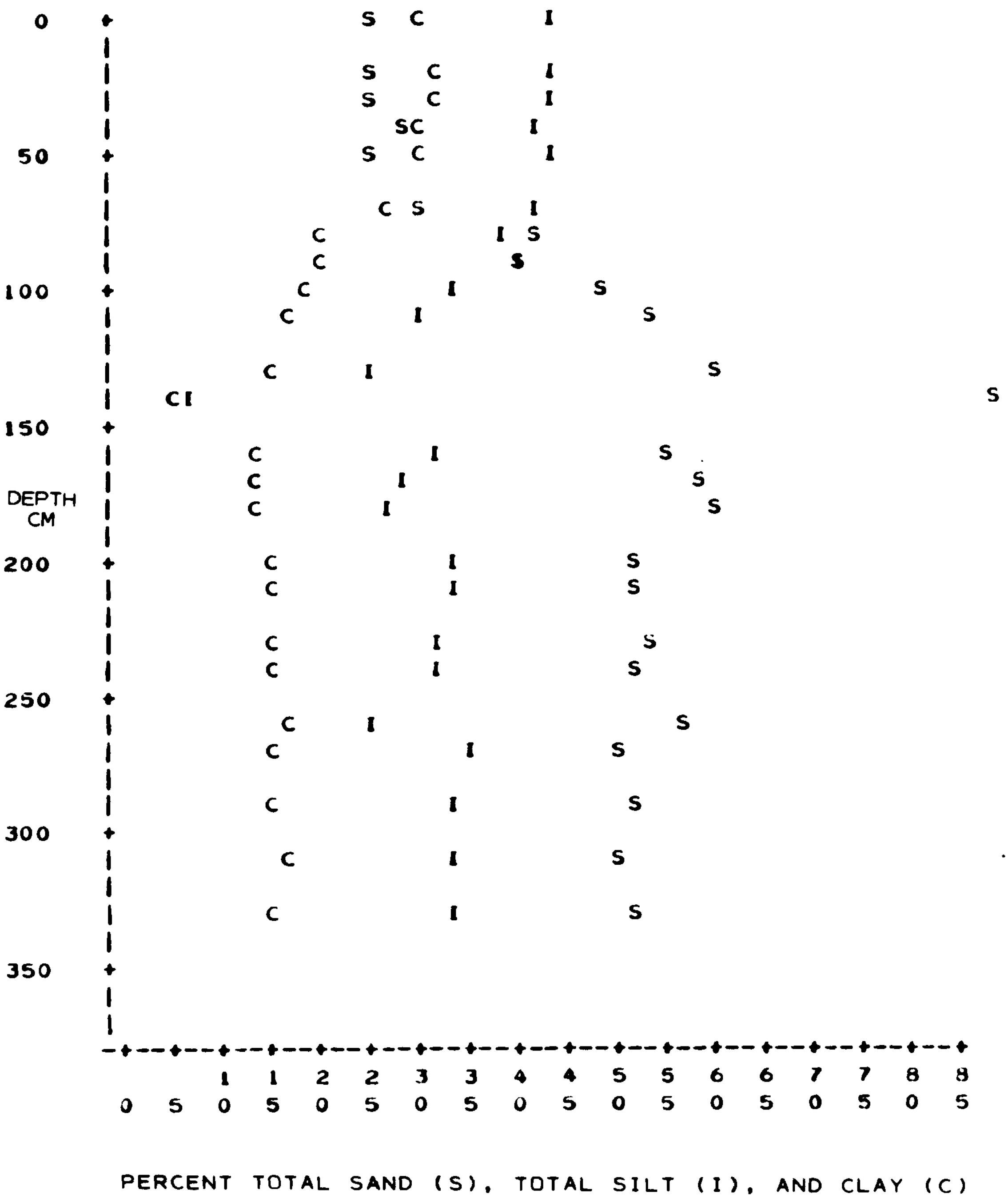


Figure 33. Distribution of sand, silt, and clay with depth for Webster in tile drained traverse

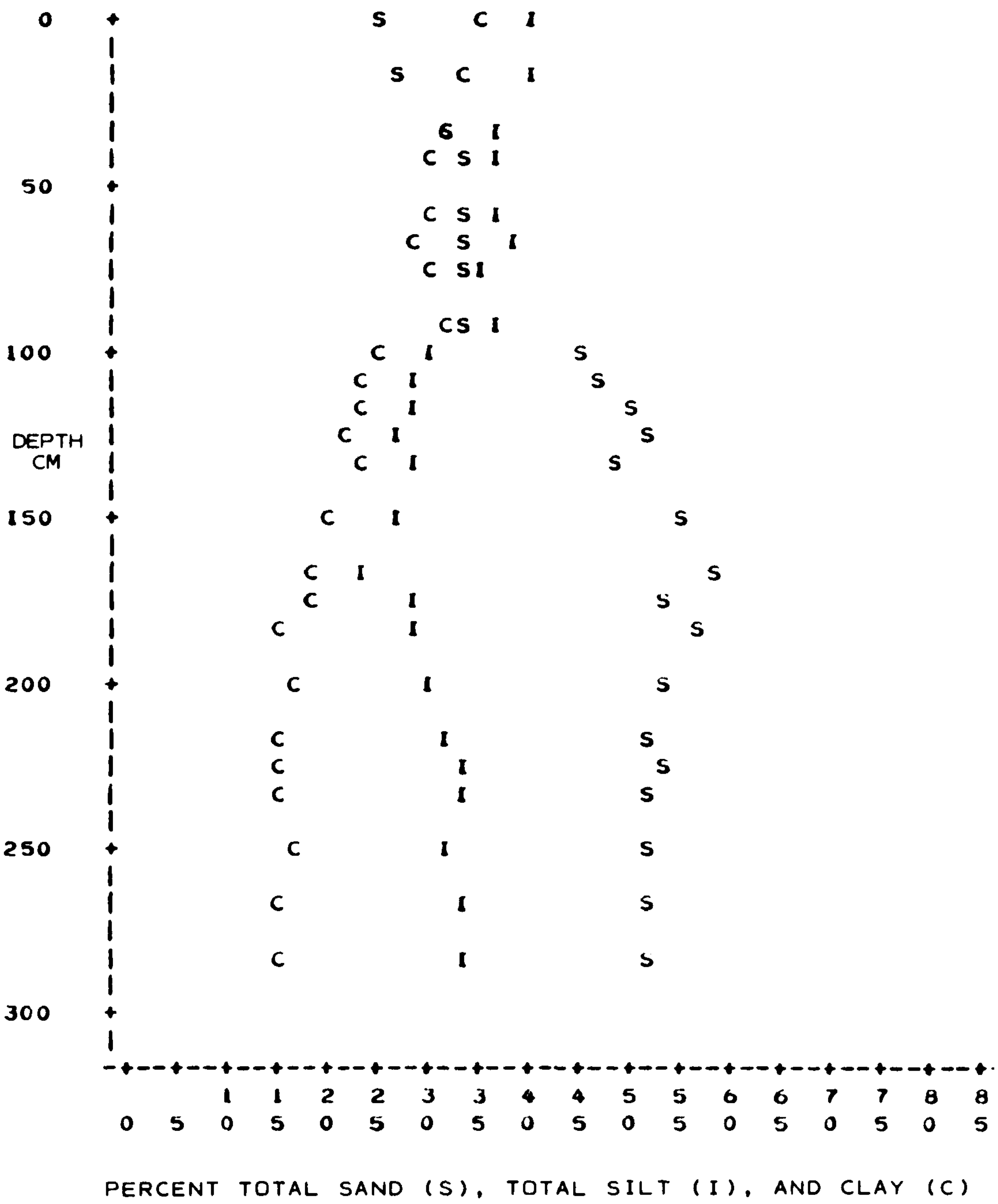


Figure 34. Distribution of sand, silt, and clay with depth for Canisteo in tile drained traverse

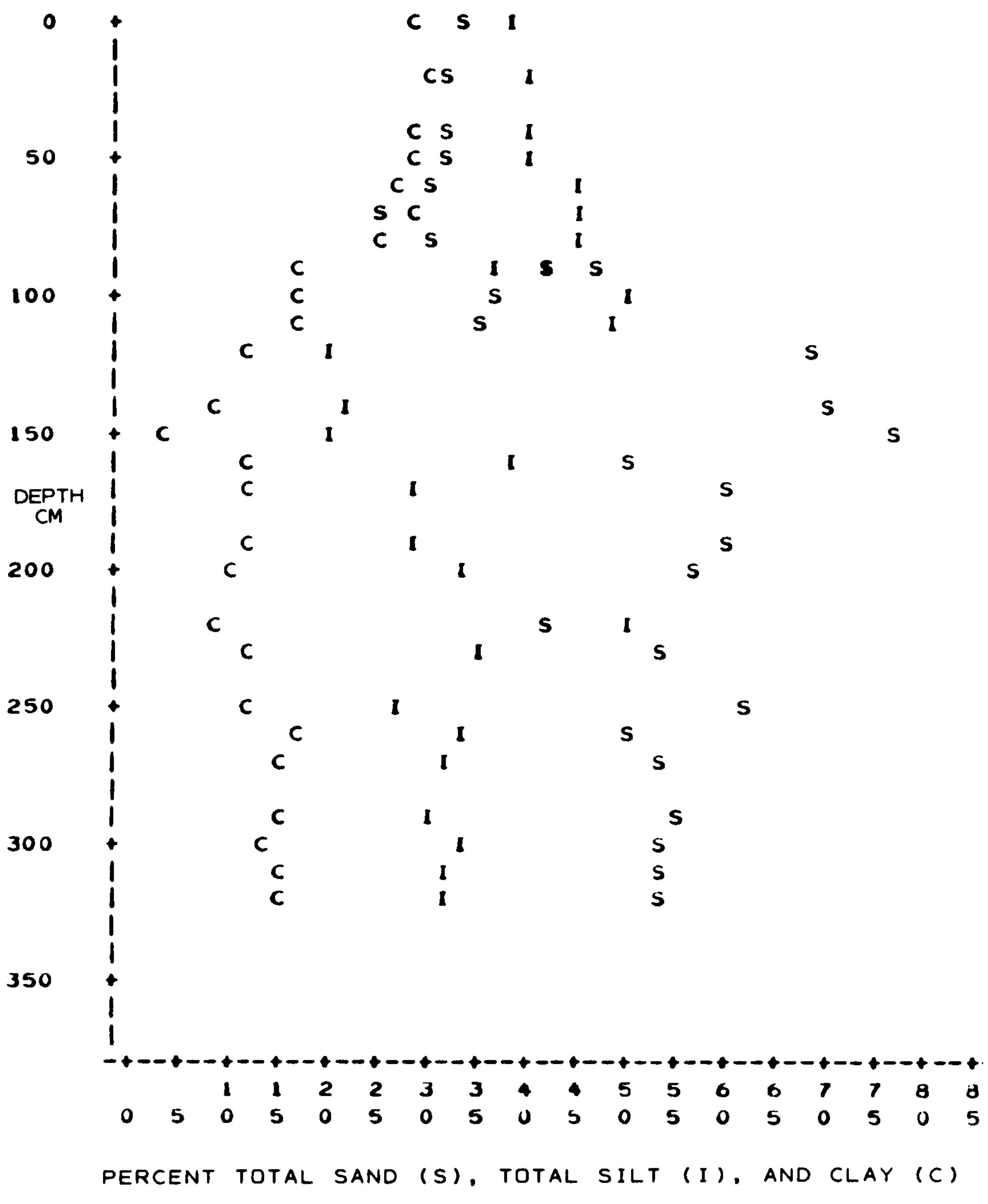


Figure 35. Distribution of sand, silt, and clay with depth for Harps in tile drained traverse

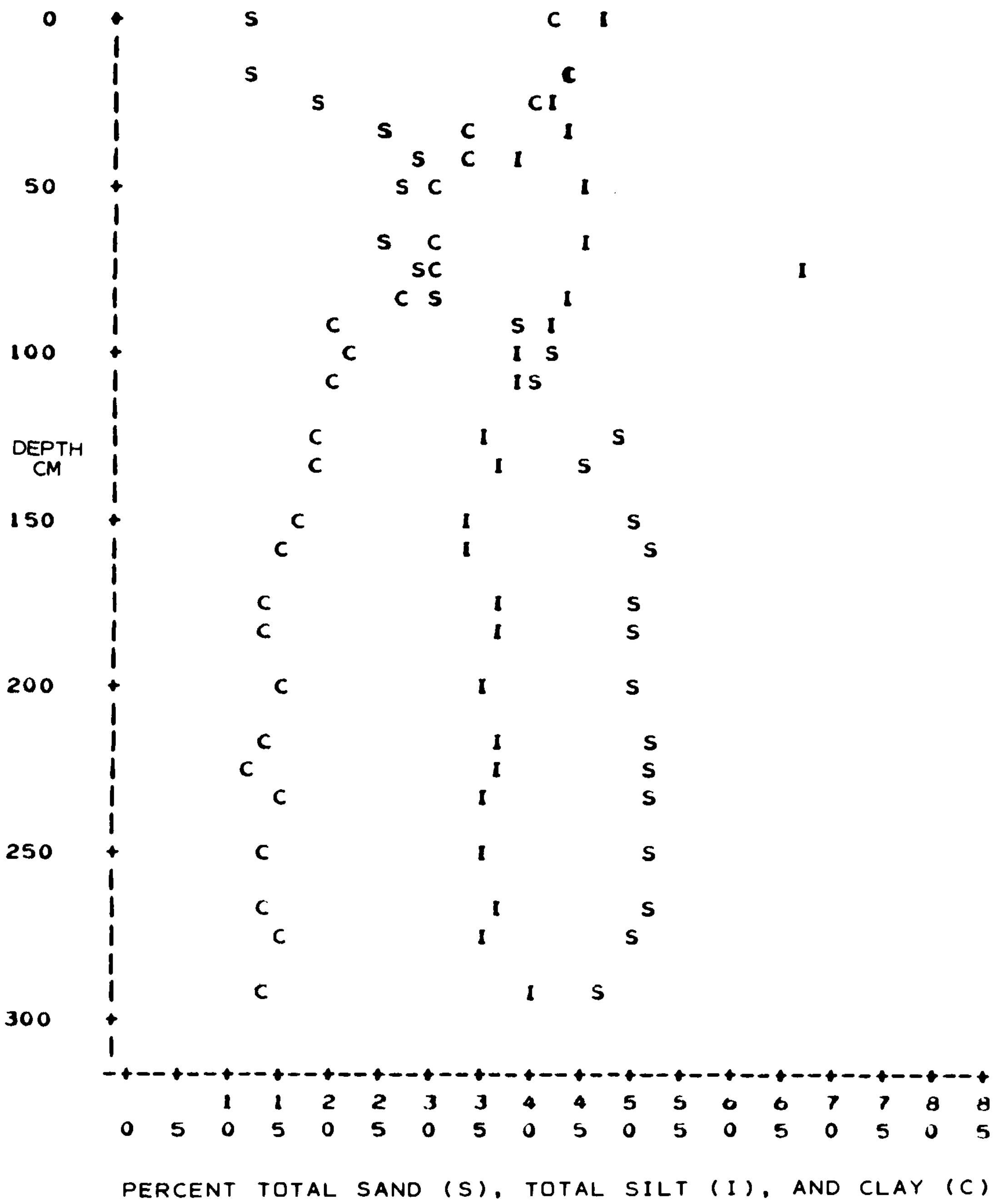


Figure 36. Distribution of sand, silt, and clay with depth for Okoboji in tile drained traverse

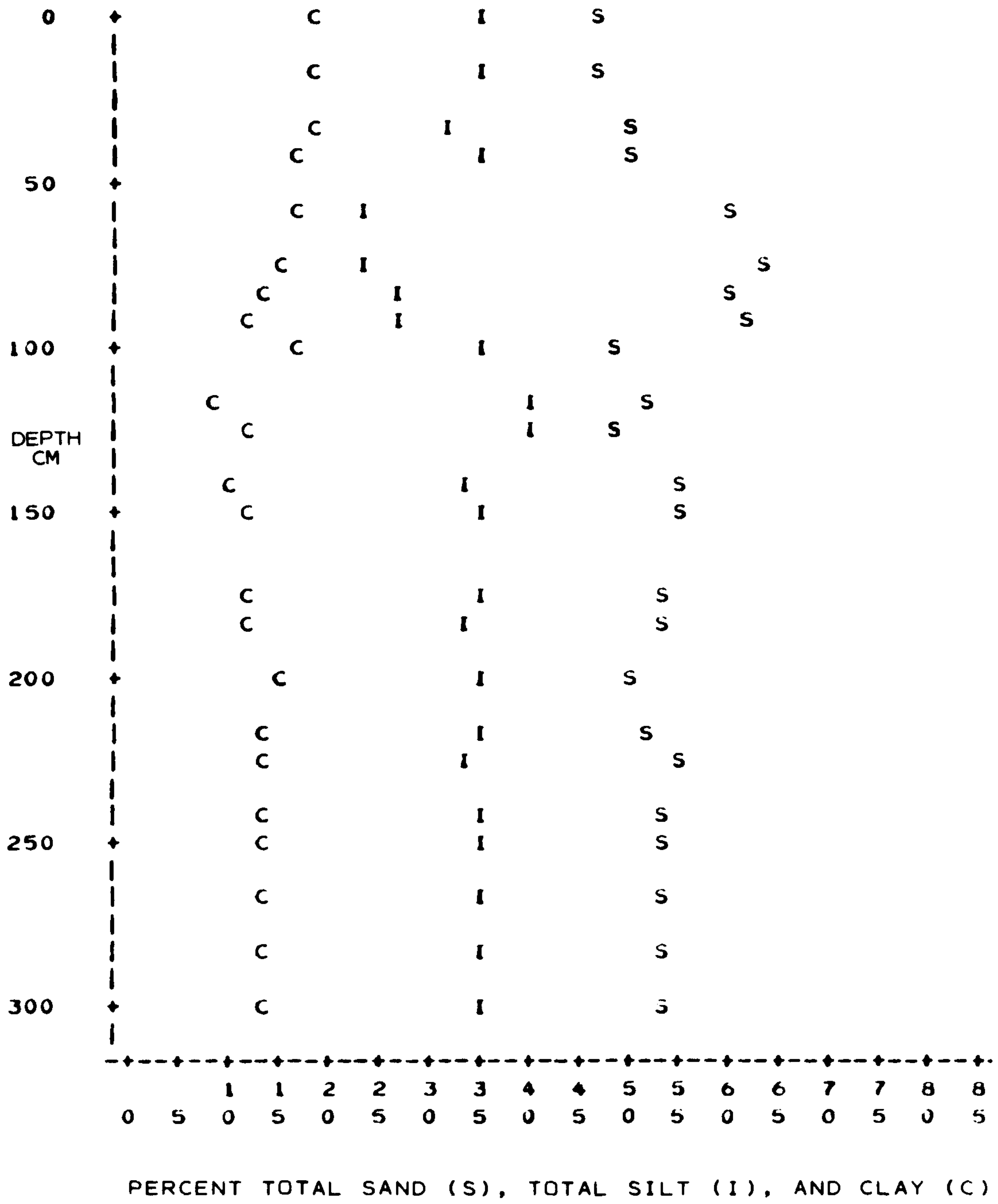


Figure 37. Distribution of sand, silt, and clay with depth for Clarion in undrained traverse

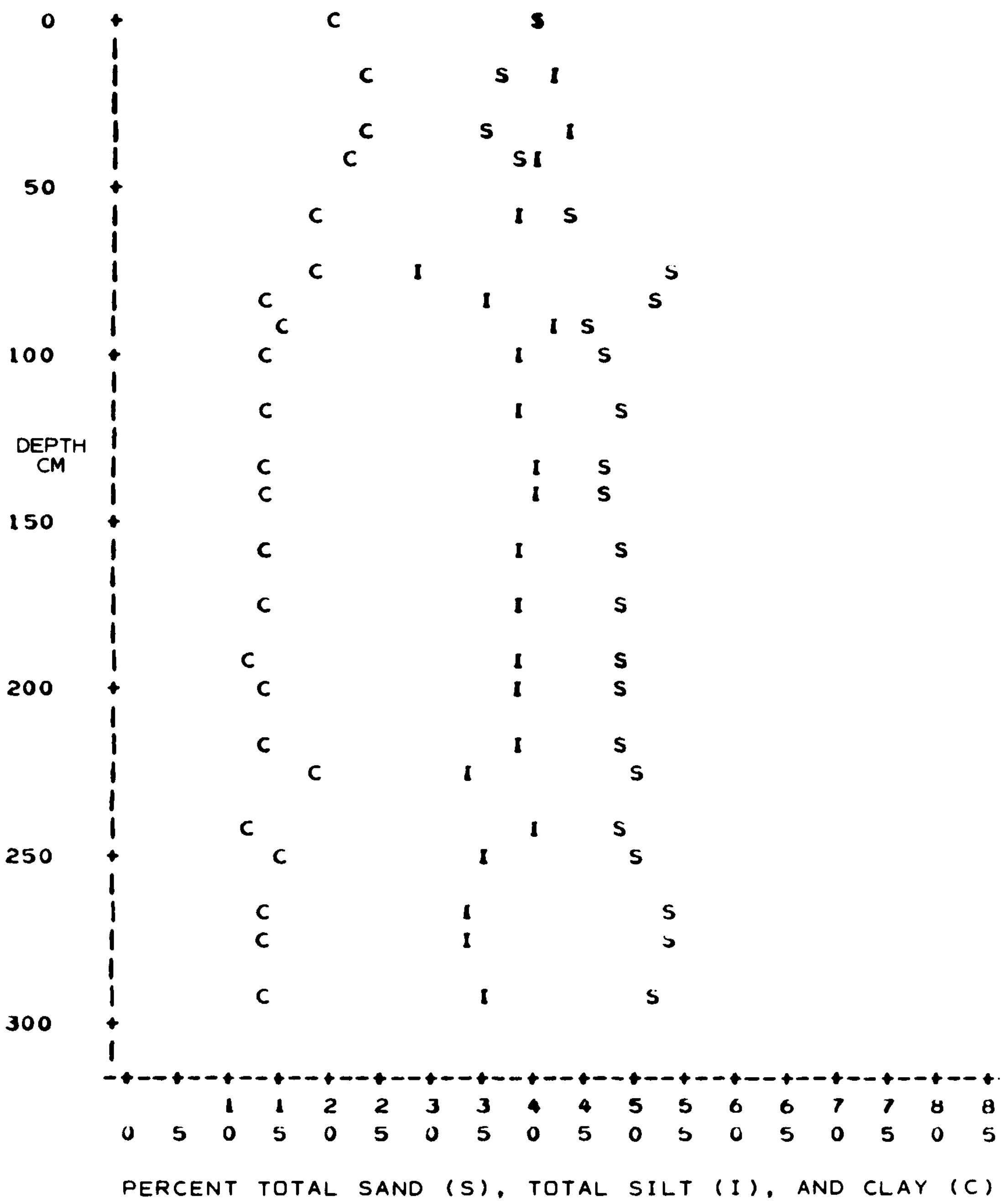


Figure 38. Distribution of sand, silt, and clay with depth for Nicollet in undrained traverse

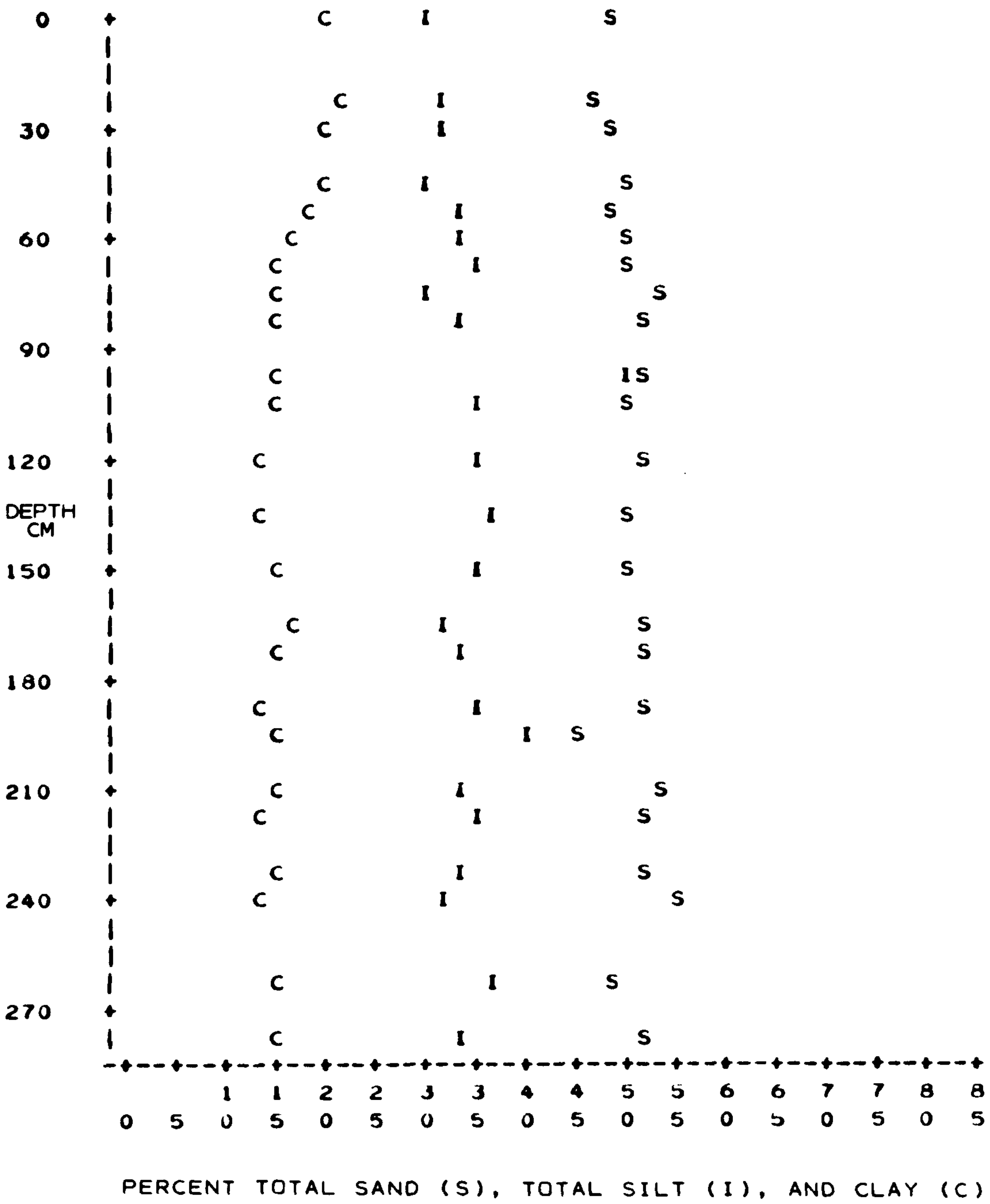


Figure 39. Distribution of sand, silt, and clay with depth for Webster in undrained traverse

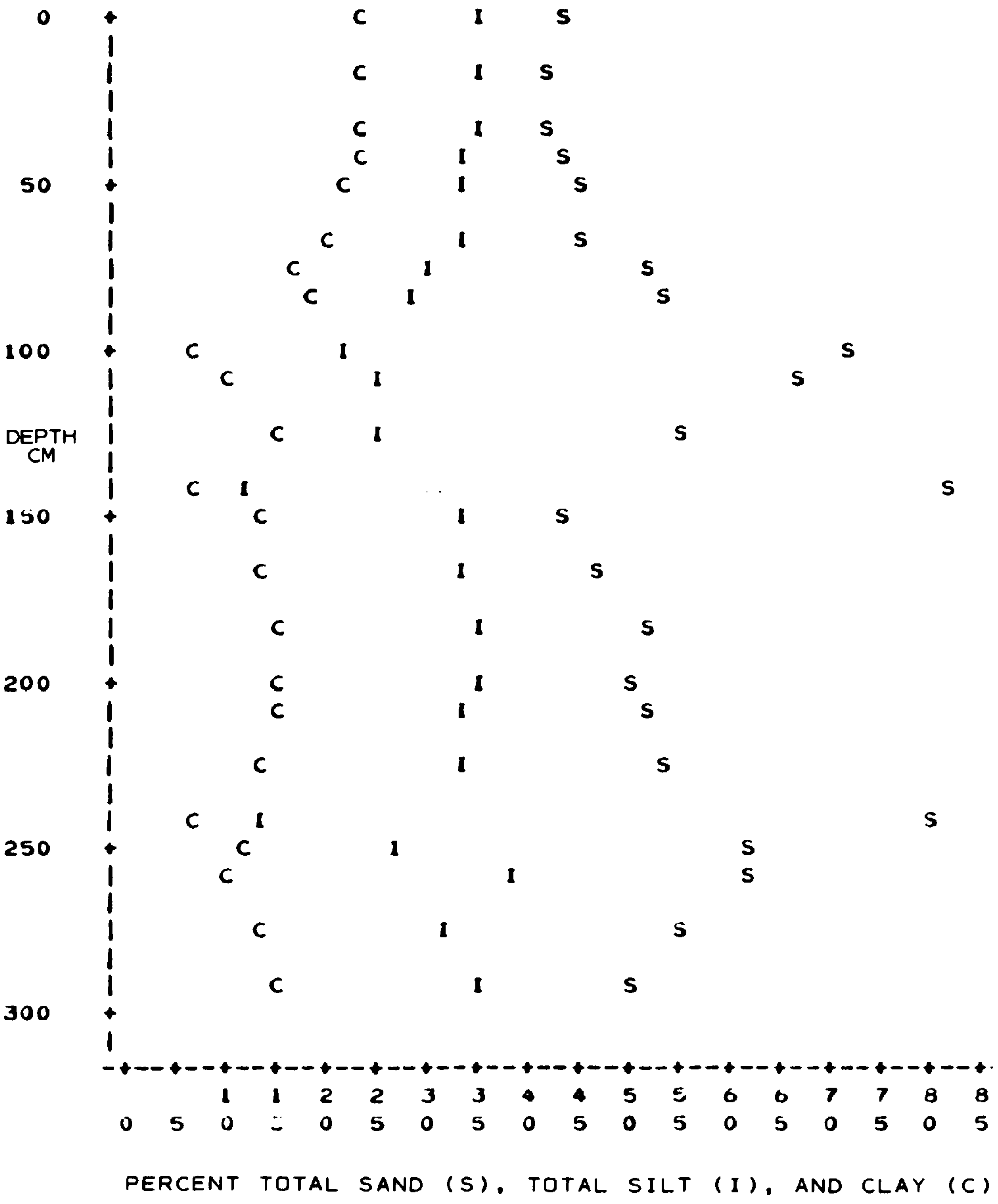


Figure 40. Distribution of sand, silt, and clay with depth for Canisteo in undrained traverse

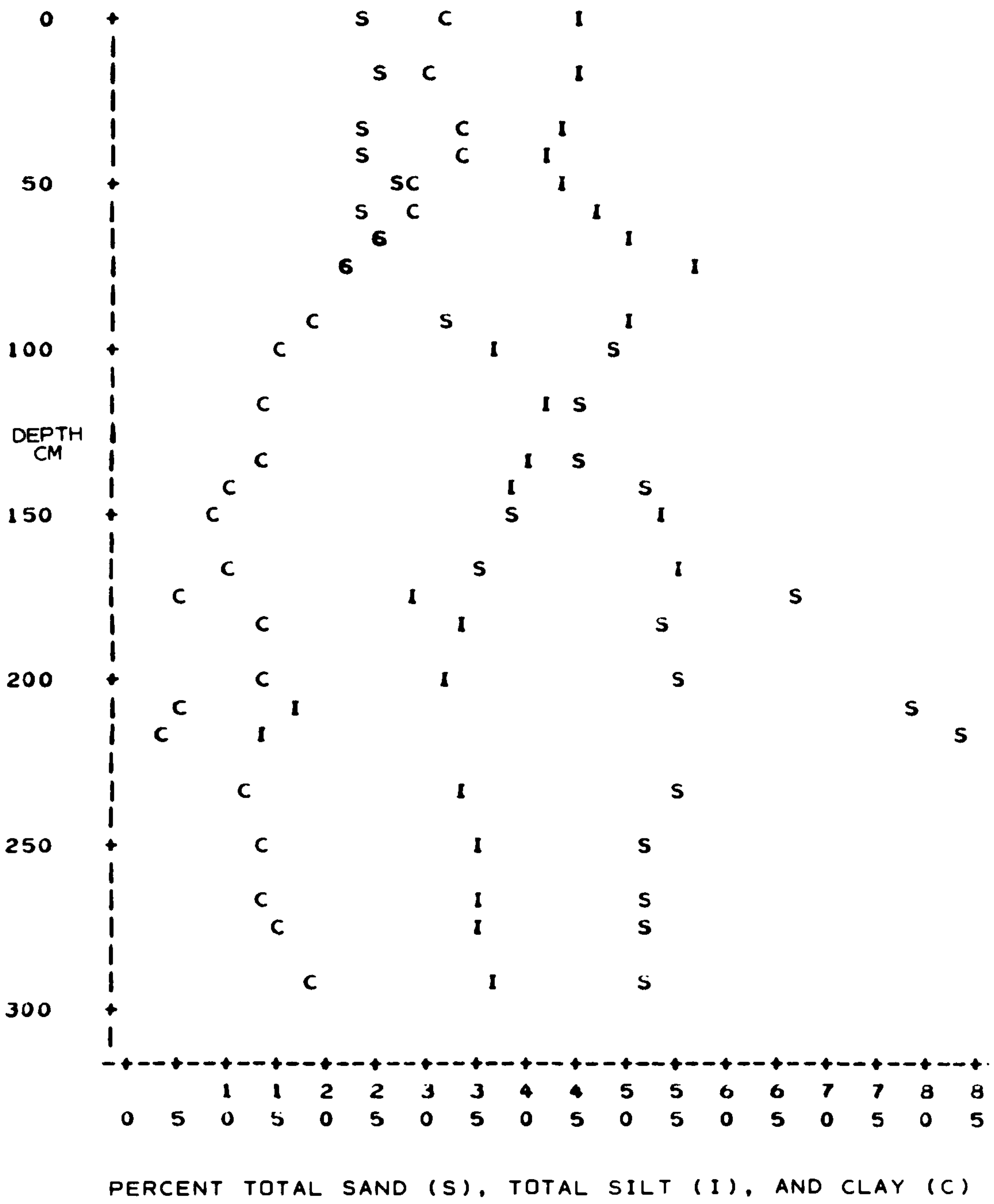


Figure 41. Distribution of sand, silt, and clay with depth for Harps in undrained traverse

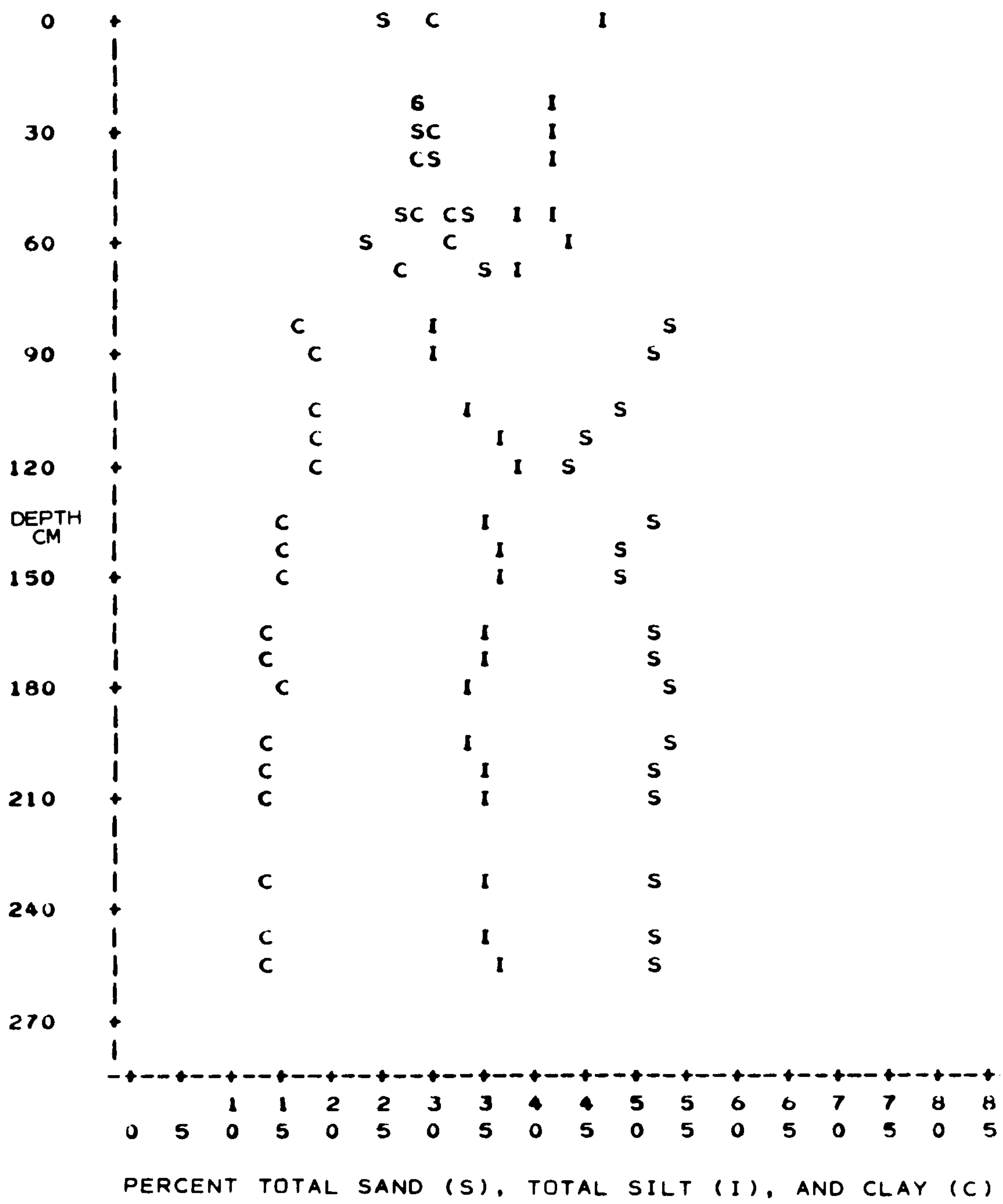


Figure 42. Distribution of sand, silt, and clay with depth for Okoboji in undrained traverse

and depositional model of Walker (1965). He also suggested that the Clarion-Nicollet-Webster toposequence formed during the last 3,000 years. Wallace and Handy (1961) also suggested the possibility that soils found on the Cary drift were not developed in Cary drift but they were formed in surficial sediment material derived from the drift. It was also assumed that soil forming processes such as additions, removals, transfers, and transformations interacted with varying degrees of importance (depending on hillslope position) with past differential erosion processes. These integrated effects were noted in all soils of both tile drained and undrained traverses.

Soil descriptions (Table B), particle size data (Table C), and chemical data (Table D), showed that all soils of both tile drained and undrained traverses fit within the range of respective official series descriptions, Soil Survey Staff.

Comparison between Soil Series in Drained and Undrained Traverses

Clarion in drained and undrained traverses

Comparison of particle size data for Clarion in the tile drained traverse (Figure 31) and particle size data for Clarion in the undrained traverse (Figure 37) showed that the surficial material is not uniform. For example, there is more variability in particle size distribution from 0 to 140 cm in the undrained Clarion. Below 140 cm, distribution of sand, silt, and clay is more uniform and similar in both Clarion profiles. The non-uniformity of material tends to support the hillslope modification model.

Clarion in the undrained traverse has about 4% more clay throughout its solum than the solum of Clarion in the tile drained traverse. This clay difference may be related to differences in the weathering environments of these two soils.

The nearly 65% total sand at 80 cm in the Clarion profile in the undrained traverse represents about 11% increase in total sand within a distance of 15 cm. This could effect the vertical movement of water through the profile. For example, rainwater percolates vertically through a fine textured material until it reaches a contrasting material. Before water moves on down through this barrier, the upper finer textured soil must almost be saturated (Gardner, 1968). Since water would tend to perch above a contrasting texture, or in this profile at 80 cm, the upper finer textured soil would be in an environment more favorable for chemical weathering for longer periods of time.

There is also more free iron in the lower B and upper C horizon in the Clarion of the undrained traverse as compared to comparable horizon of the Clarion in the tile drained traverse (Appendix D).

Morphology and laboratory data in both Clarion profiles indicated there has been little if any clay eluviation and subsequent illuviation. McCracken (1956) agreed with these findings.

Nicollet in drained and undrained traverses

Particle size distribution for Nicollet in the tile drained traverse is illustrated in Figure 32 while particle size distribution for Nicollet in the undrained traverse is shown in Figure 38. A comparison of particle size data showed there is more variability in distribution of sand, silt, and clay particles with depth in the Nicollet of the tile drained traverse. For example, this Nicollet soil has an increase of 28% sand from 90 to 140 cm. Perching of water above this sand could result. Even though a large increase in total sand was not shown for Nicollet in the undrained traverse, it contained a less significant textural variability.

Sola clay percents were different between these soils. The sola of Nicollet in the tile drained traverse had about 3% more clay than the sola of Nicollet in the undrained traverse (Table 20). Two hypotheses are presented to account for this difference.

First, clay differences may be related to differences in weathering environments of these two soils. Differences could be caused by differences in degrees of equilibrium and lengths of time it takes a given chemical weathering environment to achieve near equilibrium. This concept could possibly be applied to tile drained and undrained closed drainage systems. For example, a tile drain would remove water soluble weathering products at a faster rate than in an undrained system. Faster non equilibrium and faster weathering reactions would be associated with a tile drained system. In an undrained system where weathering products could not be leached out, a quasi-equilibrium is established quickly. The net result would be less clay formation for Nicollet in the undrained traverse.

Second, differences in percent clay throughout the sola of these Nicollet profiles may be due to textural variations within the till. Bear (1964) reported that the rate of clay formation even under the

Table 20. Average percent clay for A and B horizons for all soils in tile drained and undrained traverses

Horizon		Clarion % Clay	Nicollet % Clay	Webster % Clay	Canisteo % Clay	Harps % Clay	Okoboji % Clay
A	Drained	18.23	25.90	31.13	33.33	28.70	36.97
A	Undrained	22.25	23.48	21.05	23.20	31.67	29.02
B	Drained	14.22	21.67	25.64	27.55	23.58	23.64
B	Undrained	18.55	17.95	17.02	16.74	25.90	22.75

most intensive weathering conditions ranged from 0.0001 to 0.002 grams per 100 grams parent material, per year. It would be difficult to relate 80 to 100 years of tiling with a difference in clay of 3%. Tiling could contribute to faster rates of clay formation and translocation.

Webster in drained and undrained traverses

Webster in the drained traverse (Figure 33) and Webster in the undrained traverse (Figure 39) have differences in particle size distribution. More variability in distribution of total sand was shown for Webster in the tile drained traverse. There is an increase in total sand of about 40% from 110 to 140 cm for Webster in the tile drained traverse. A comparable increase of total sand is not present in the Webster profile of the undrained traverse.

Clay content between sola of these Webster profiles was different. For example, Webster in the tile drained traverse had about 9% more clay than Webster in the undrained traverse (Table 20). In Part I, it was shown that water tables were higher in the profile for longer periods of time in Webster in the undrained traverse than Webster in the tile drained traverse. The same hypotheses proposed in the Nicollet discussion are also applicable for explaining differences in percent clay in the Webster solum.

Canisteo in drained and undrained traverses

Both Canisteo in the tile drained traverse (Figure 34), and Canisteo in the undrained traverse (Figure 40), showed variability in particle size distribution. More variability in percent total sand is shown for Canisteo in the undrained traverse. For example, it has a total sand increase of 32% from 70 to 110 cm. This magnitude of percent total sand was not found for the Canisteo in the tile drained traverse.

Clay contents between Canisteo sola differed. The Canisteo in the tile drained traverse contained about 10% more clay than Canisteo in the undrained traverse (Table 20). Possible reasons for these differences relate to hypotheses presented in the Nicollet discussion.

Harps in drained and undrained traverses

Particle size distribution for both Harps in the tile drained traverse (Figure 35) and Harps in the undrained traverse (Figure 41) showed a large amount of variability in percent total sand. It is obvious that these differences are due to variability of till.

Clay content in the sola for Harps in the undrained traverse (Table 20) is about 3% more than clay content of Harps in the drained traverse. The slightly increased percent clay for Harps in the undrained traverse could be due to carbonate size clay. Water moving laterally would transport soluble carbonates from higher to lower hillslope positions. Mendenhall (1967) suggested that part of the high carbonate content in the Harps was due to evaporation of water which resulted in an accumulation of carbonates. A tile drain would tend to drain water containing soluble carbonates while water would evaporate in the undrained Harps hillslope position. The net result could explain the 3% higher clay content for Harps in the undrained traverse.

Okoboji in drained and undrained traverses

Distribution of particle size for Okoboji in the tile drained traverse and Okoboji in the undrained traverse was variable. Percent of total sand increased 40%, and clay decreased 25% from 0 to 120 cm for Okoboji in the tile drained traverse. These sand and clay changes with depth were not present for Okoboji in the undrained traverse. Clay content in sola of both drained and undrained Okoboji were similar (Table 20).

Throughflow - Water Movement

The amount of water moving through a porous media is described by the following relationship (Bouma, et al. 1974).

$$Q = KA \frac{h_2 - h_1}{L} \tag{1}$$

Darcy's law states that Q is the volume of water flowing through a specified area such as 1 ft^2 in a given amount of time; units are in cubic inches per hour. K is the media's hydraulic conductivity, and is expressed in inches per hour. A defines the area or window. The hydraulic gradient is defined as change in height ($h_2 - h_1$) over a distance of L.

The average velocity is expressed as

$$V^1 = \frac{Q}{Ew} \tag{2}$$

where V^1 is average velocity, Q is volume and Ew is the water filled porosity. These equations describe water movement through soil in both unsaturated and saturated conditions. Permeability rates, or K values for the A and B horizons in soils of this study are similar. Russell et al. (1974) list a permeability value of 0.63 to 2.00 inches per hour for sola of Clarion, Nicollet, Webster, Canisteo, and Harps. A permeability of 0.20 - 0.63 and 0.06 - 0.63 is reported for the A and B horizon, respectively, of the Okoboji.

A study by Cleaves et al. (1970) of a watershed on the Piedmont in Maryland showed that chemical solution was five times more effective in moving soluble weathering products from a soil system than mechanical erosion. For example, they reported 16.9 tons of solids per square mile was removed by solution weathering while only 3.2 tons of solids per square mile was removed by mechanical erosion. Their findings of lateral movement of water can be applied to this study.

By substituting values into Darcy's law, it is possible to estimate the impact of chemical solution weathering of an artificially drained system. The following values were selected: K = 2.0 in/hr, A = 144 in^2, and the hydraulic gradient is 3% over a length of flow of 1200 inches.

$$Q = (2 \text{ in/hr})(144 \text{ in}^2)\left(\frac{36 \text{ in}}{1200 \text{ in}}\right) = 8.64 \text{ in}^3/\text{hr}$$

$$V^1 = \frac{8.64 \text{ in}^3/\text{hr}}{144 \text{ in}^2} = 0.06 \text{ in/hr (assuming Ew} = 144 \text{ in}^2).$$

Therefore, in one day, total flow through one ft^2 under a 3% slope = 207.36 in^3. If this water contains 400 ppm of dissolved solids, a total amount of solids removed from this system through a 1 sq. ft area is 0.00299 lb/day. Projecting this amount back in time to when the tile system was installed some 80 years ago, and considering the total area involved, would mean that large amounts of material have been removed through the tile drain. It appears that the artificial drain has modified weathering processes significantly. In order to confirm this hypothesis, it would be necessary to monitor water flowing through the tile.

Particle size data suggest that a continuous layer or strata high in total sand extends from Nicollet through Harps in both drained and undrained traverses. For example, this layer at 90 to 190 cm in Nicollet extends through Webster and eventually into Harps at 100 to 150 cm, tile drained traverse. This continuous layer is not as prominent in the undrained traverse. Once percolating water entered one of these layers, lateral movement would accelerate.

Phosphorus Distribution

Distribution of phosphorus within soil profiles for individual members of both tile drained and undrained traverses (Figures 43 through 48 and Figures 49 through 54, respectively) showed differences in relative magnitude of total phosphorus redistribution. Godfrey and Riecken (1954), Runge and Riecken (1966), Smeck and Runge (1971), and Smeck (1973) have studied distribution of phosphorus within soils. Their studies included selected soil series which provided information on differences in total, organic, and available phosphorus distribution resulting from differences in time, drainage, climate, vegetation, and parent material. These researchers related phosphorus distribution to the five soil forming factors. Smeck (1973) related phosphorus redistribution to water movement both vertically and laterally through soil.

Inspection of distribution of total phosphorus curves for all soils in both tile drained and undrained traverses showed an average total phosphorus for C horizons of 350 ppm. A reference line at 350 ppm total phosphorus is drawn vertically through all phosphorus distribution curves for all soils in both drained and undrained traverses. This reference line makes it easier to compare relative amounts of total phosphorus redistribution. Since there was a possibility that man had incorporated phosphorus fertilizer into the Ap horizons of these soils, phosphorus comparisons started at the base of this horizon. The base of the Ap horizon is uniformly at a depth of 20 cm (Appendix B). Phosphorus distribution plots were developed from data contained in Appendix D.

Total phosphorus distribution for Clarion in drained and undrained traverses

Data suggested that between these two Clarion lower A and B horizons, the lower A and B horizon of the Clarion in the undrained traverse

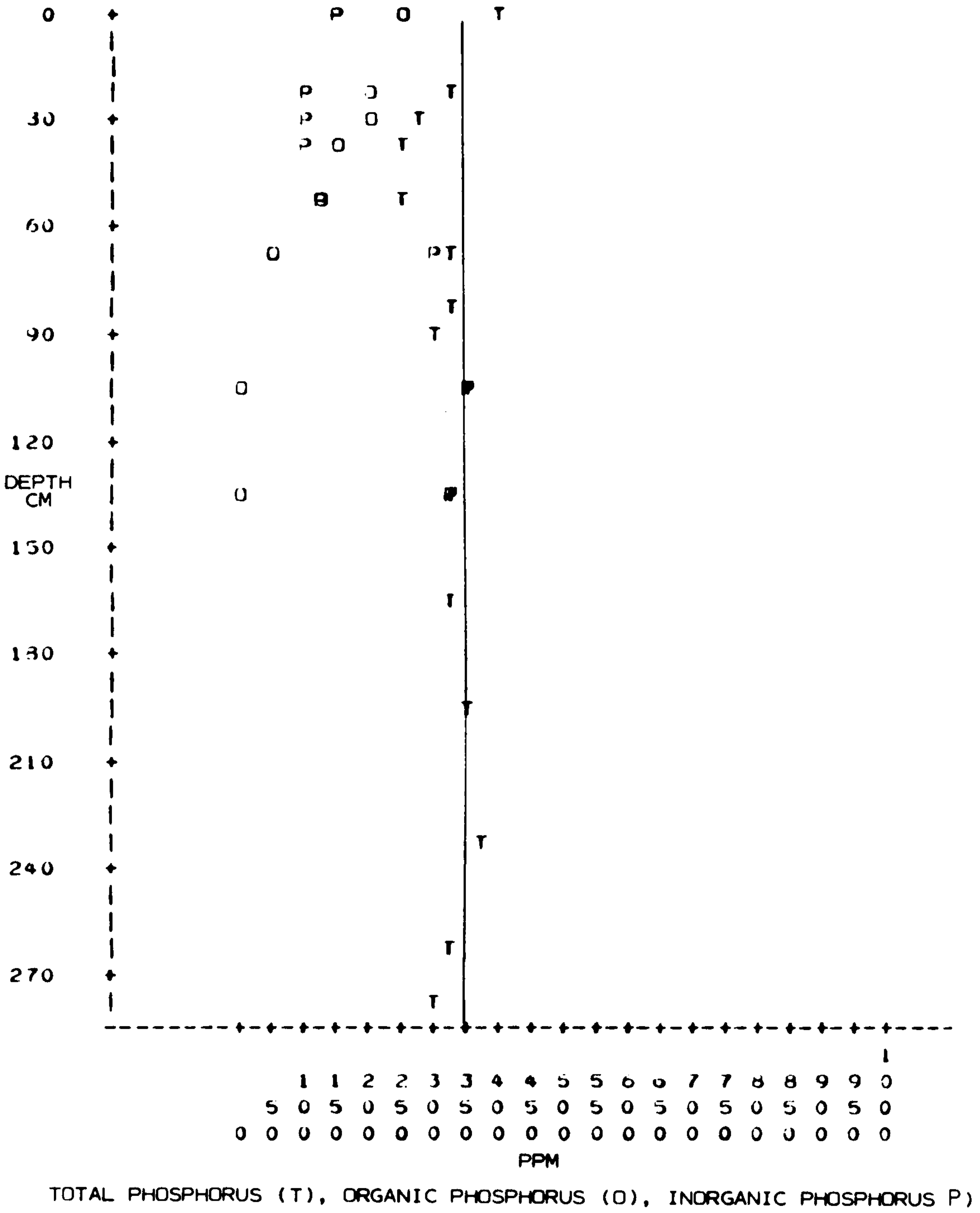


Figure 43. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Clarion in tile drained traverse

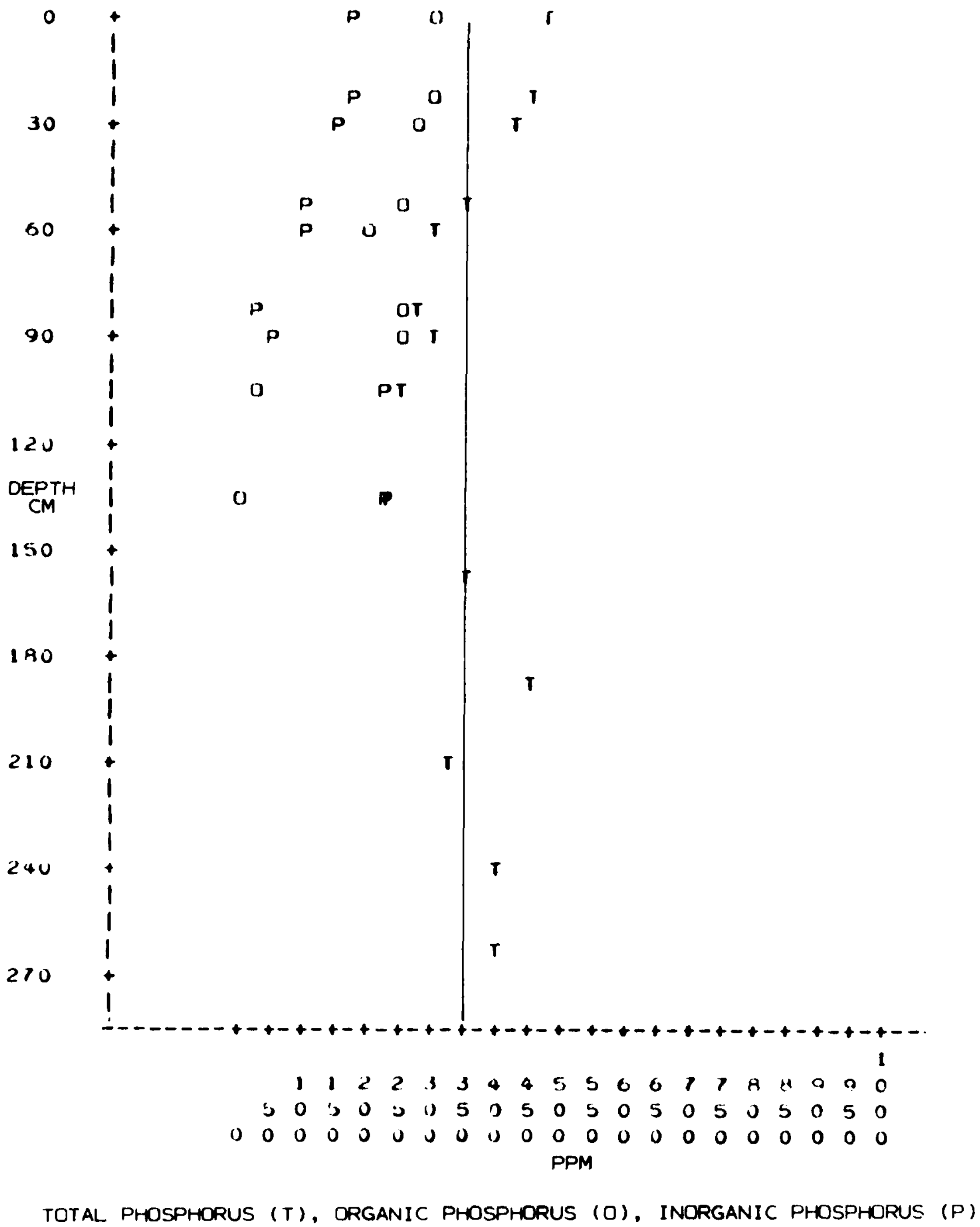


Figure 44. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Nicollet in tile drained traverse

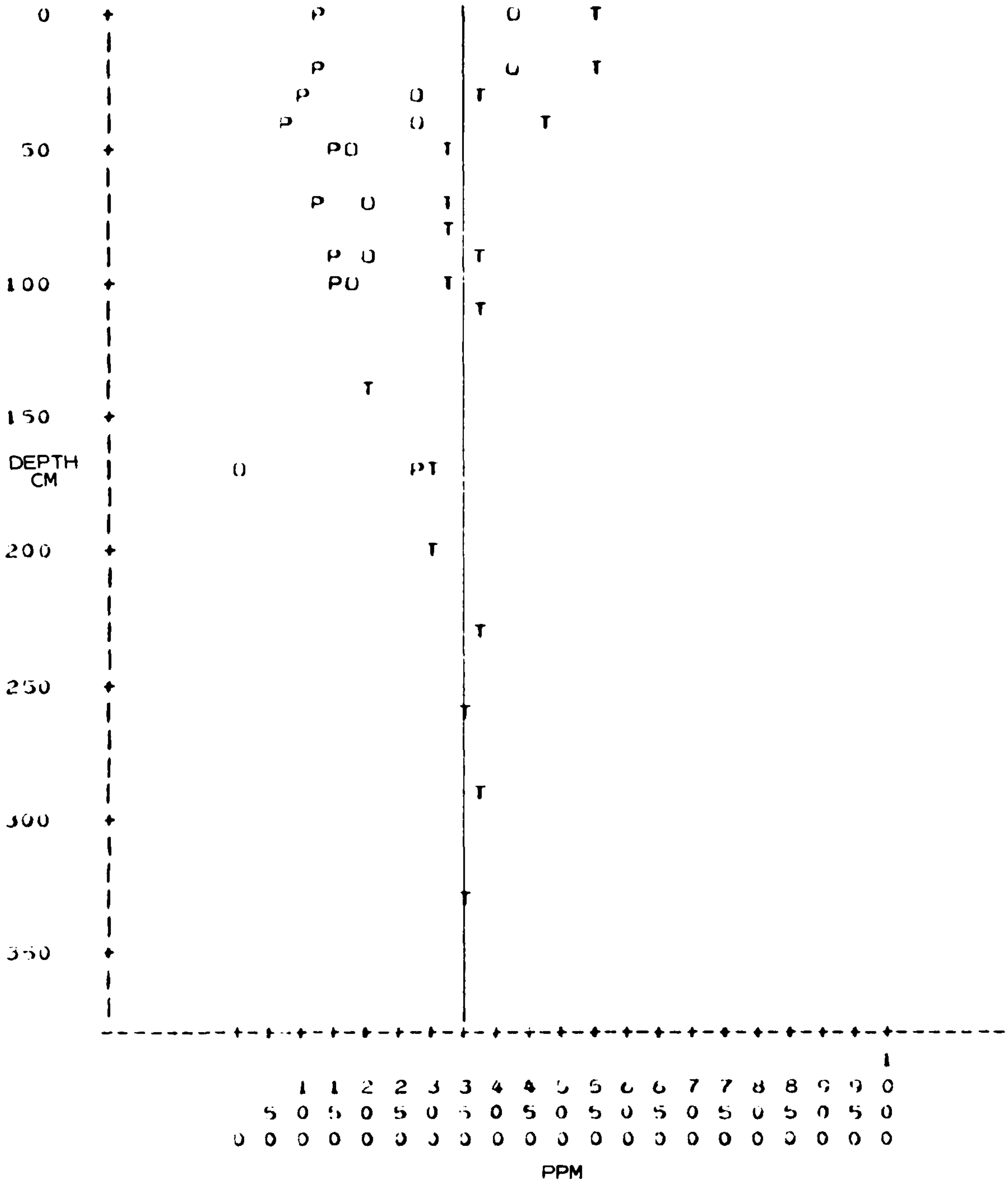


Figure 45. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Webster in tile drained traverse

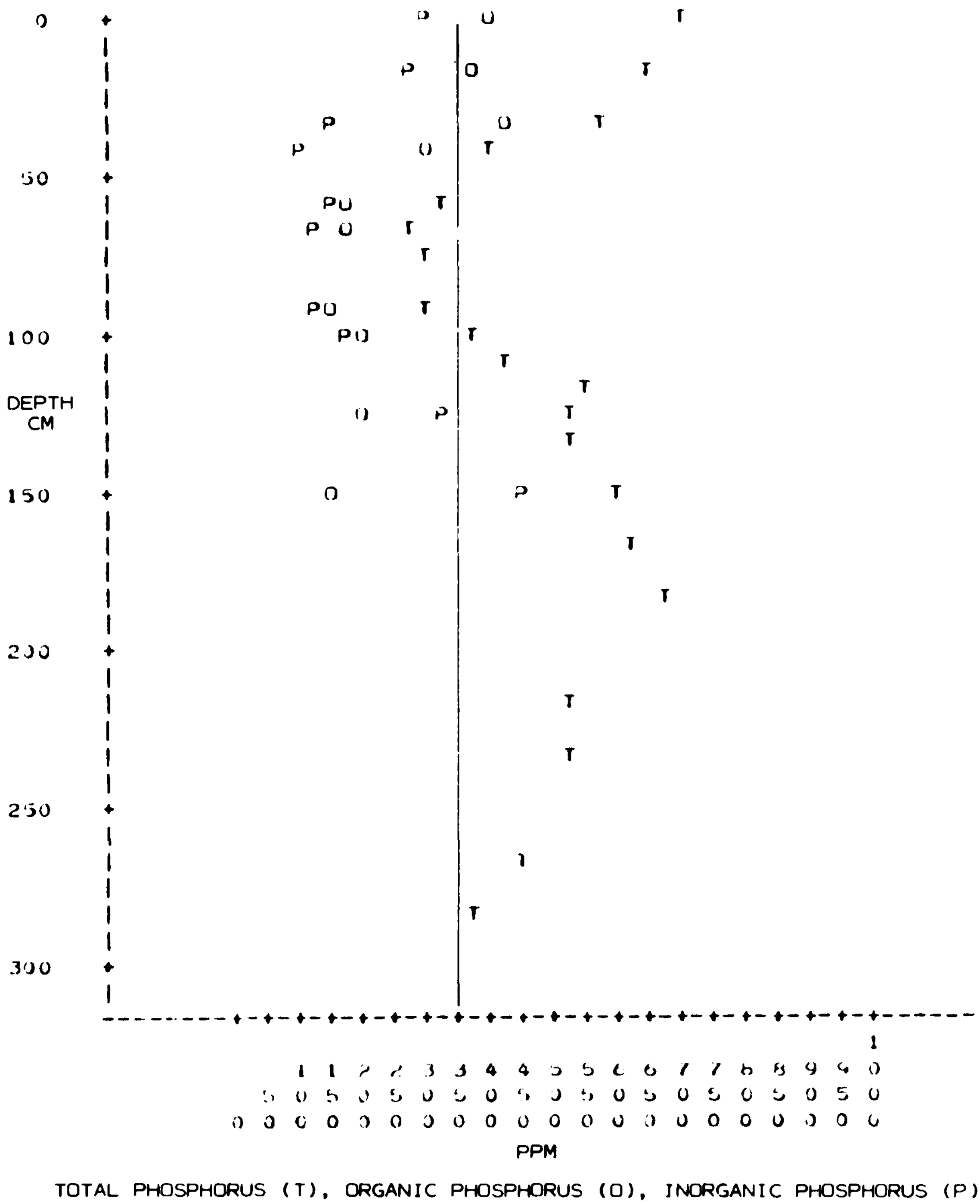


Figure 46. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Canisteo in tile drained traverse

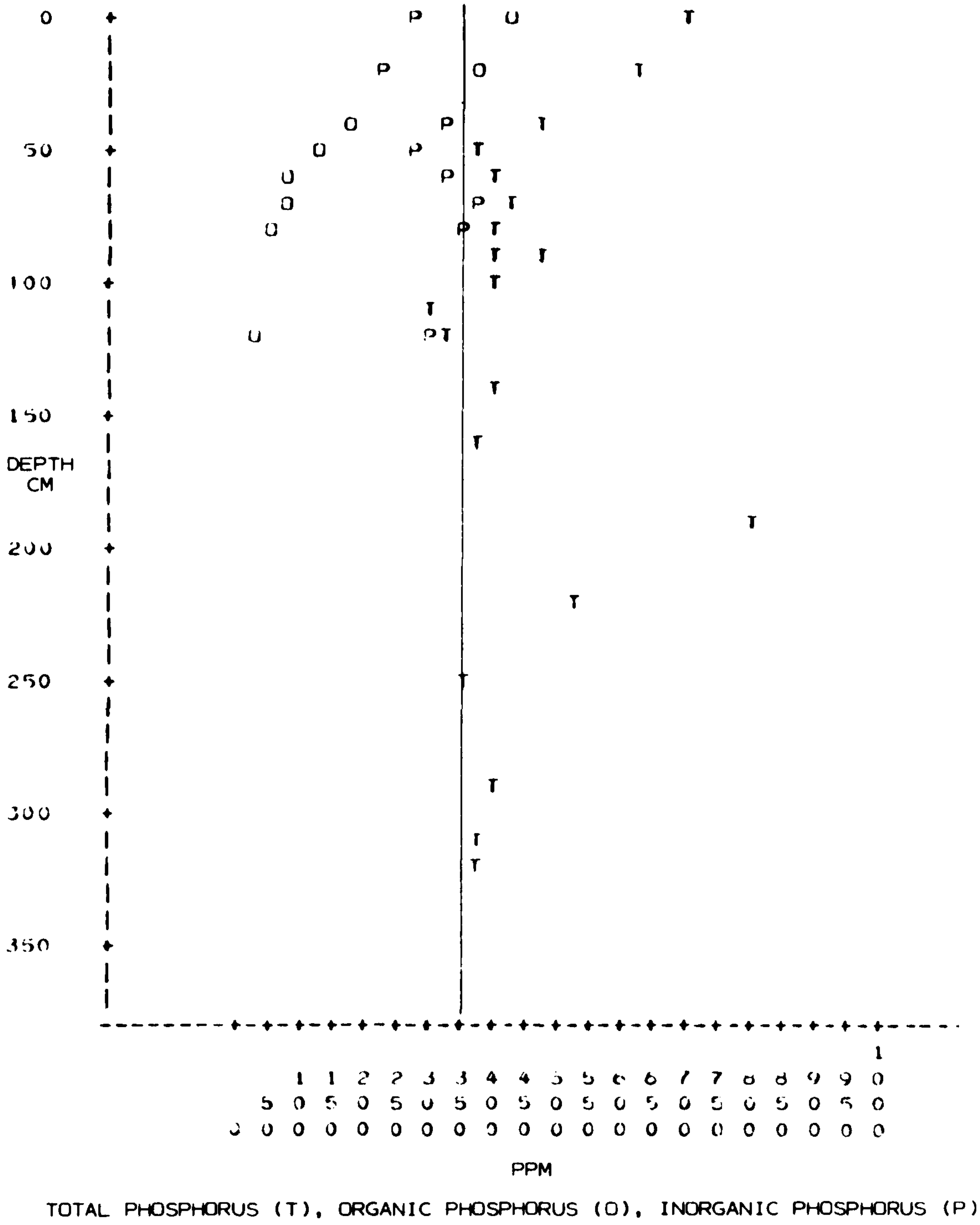


Figure 47. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Harps in tile drained traverse

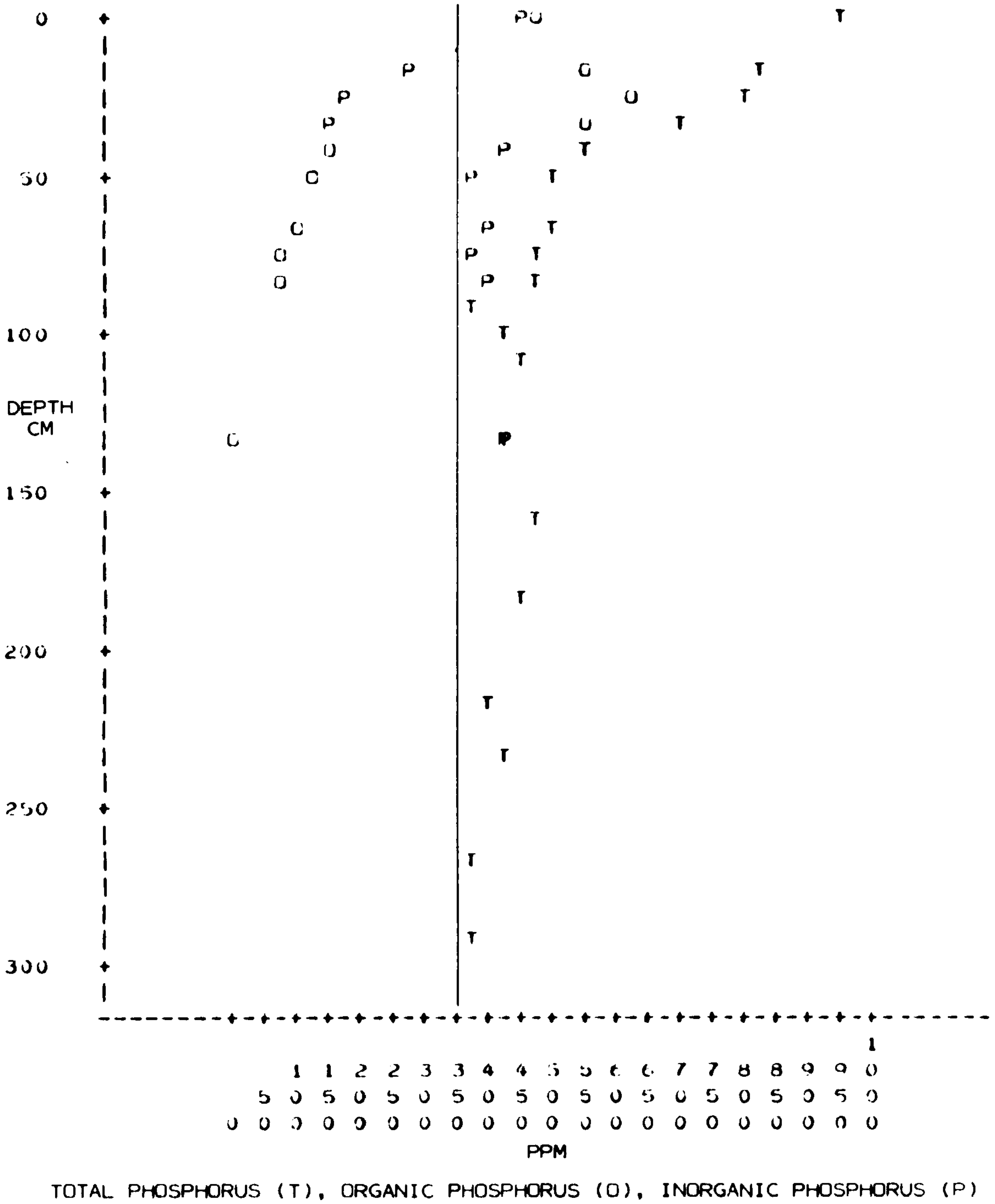


Figure 48. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Okoboji in tile drained traverse

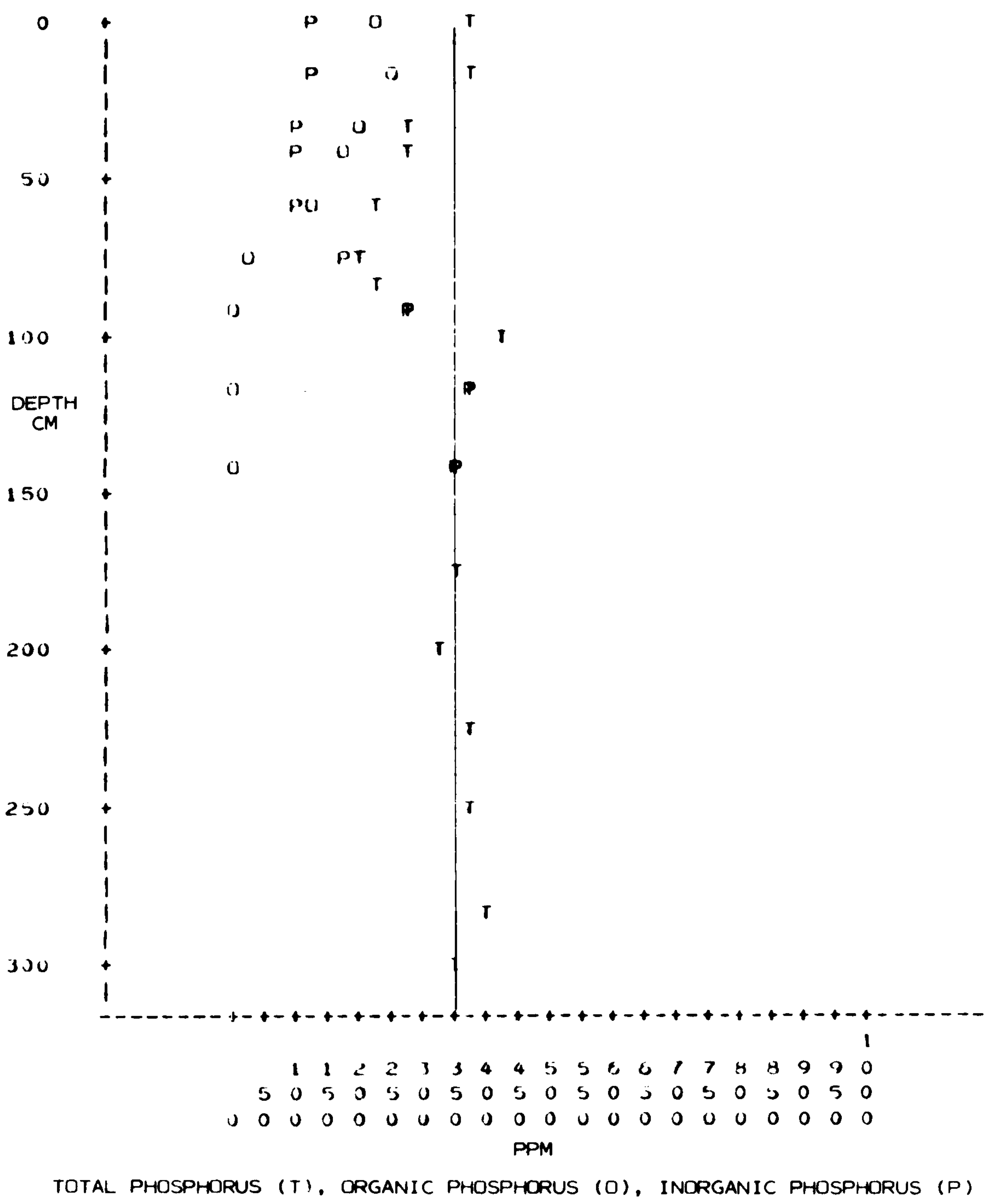


Figure 49. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Clarion in undrained traverse

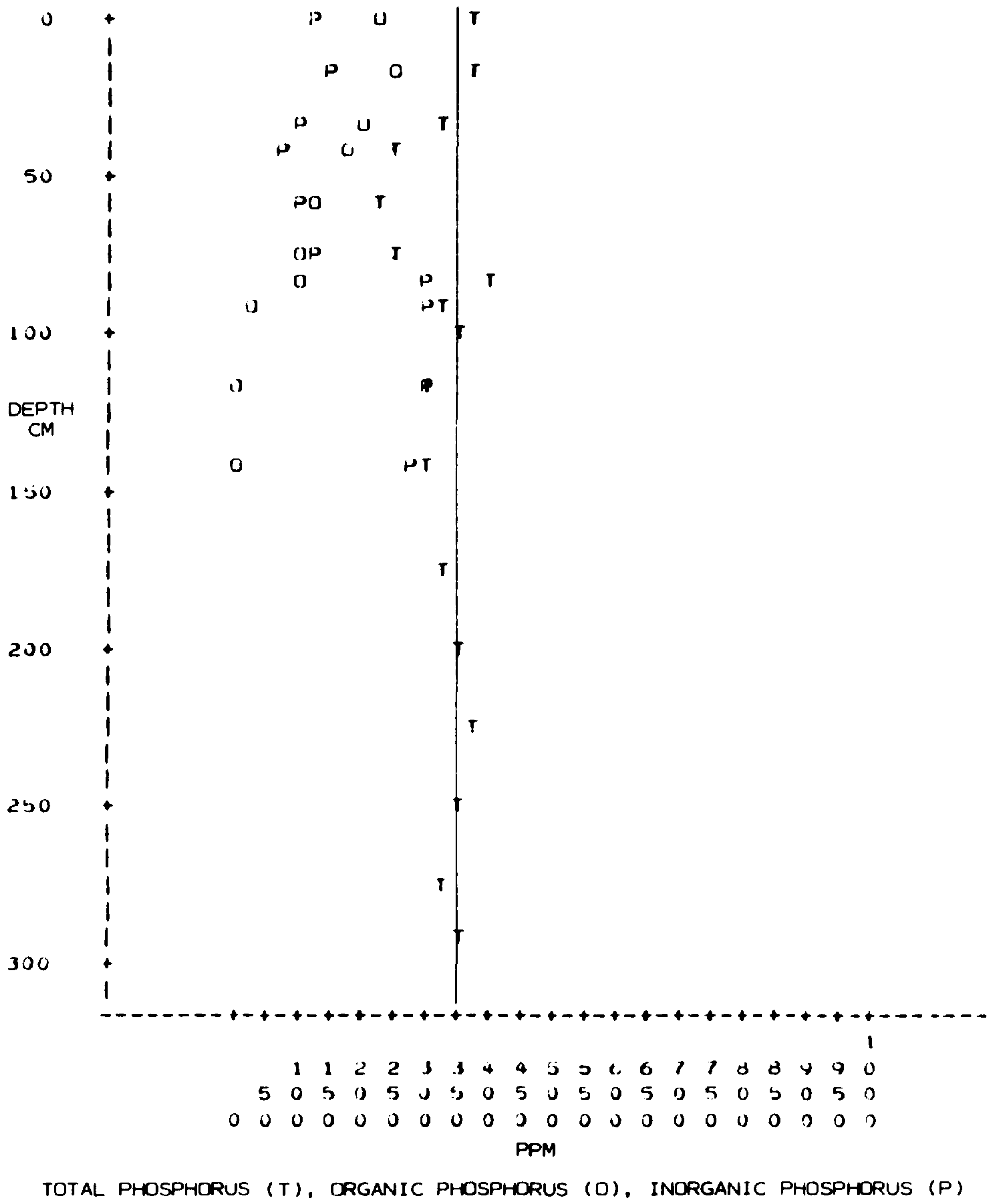


Figure 50. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Nicollet in undrained traverse

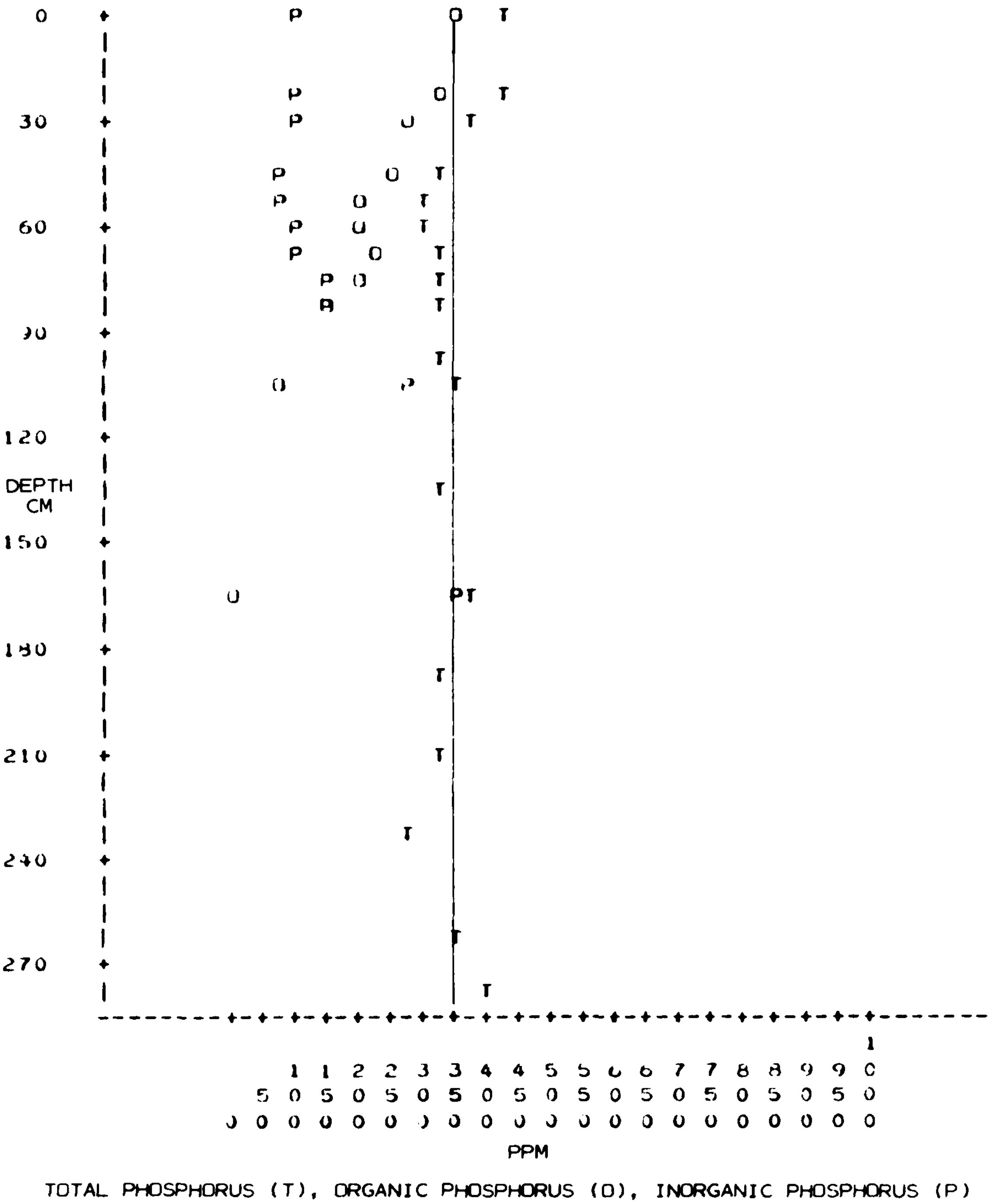


Figure 51. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Webster in undrained traverse

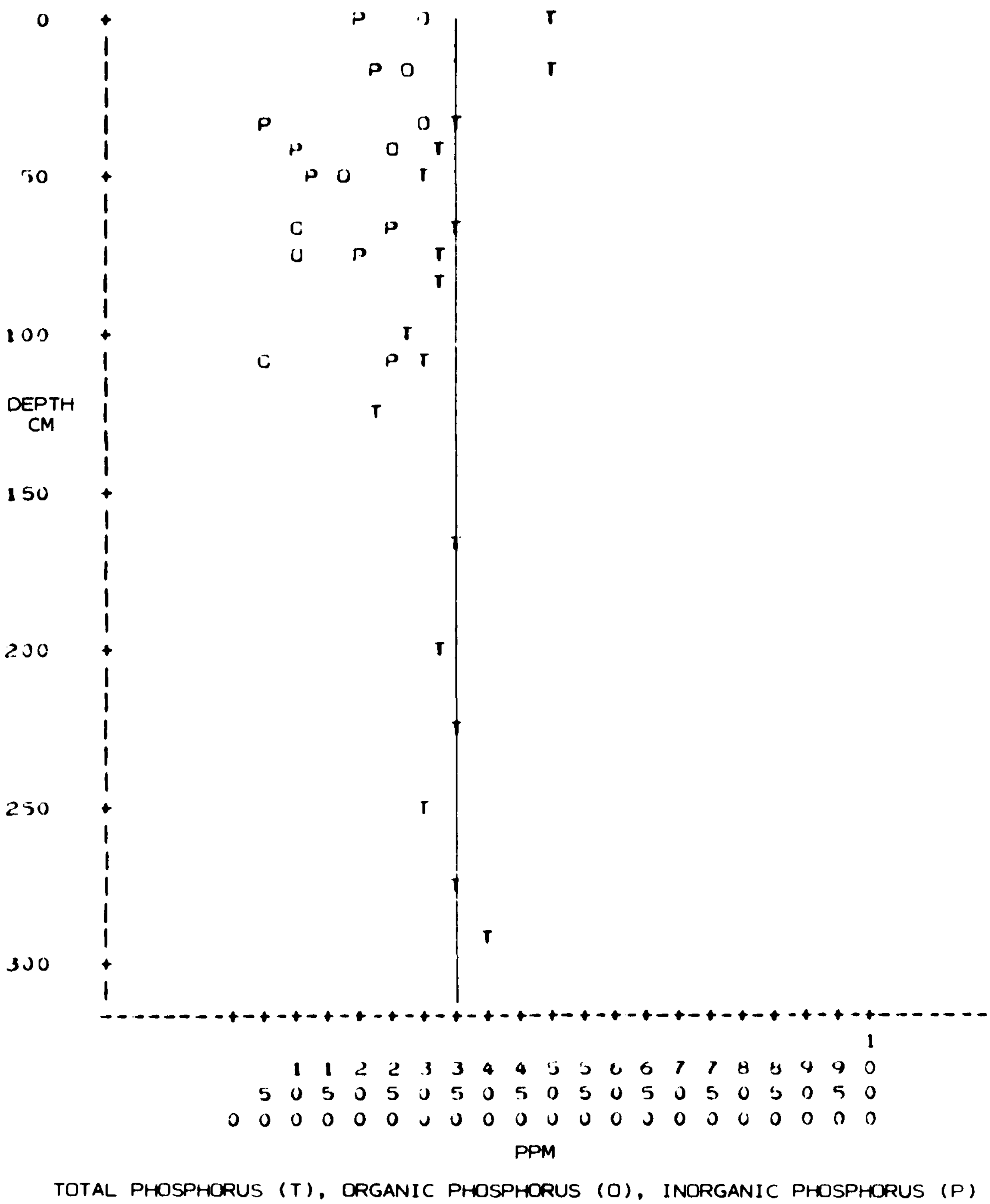


Figure 52. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Canisteo in undrained traverse

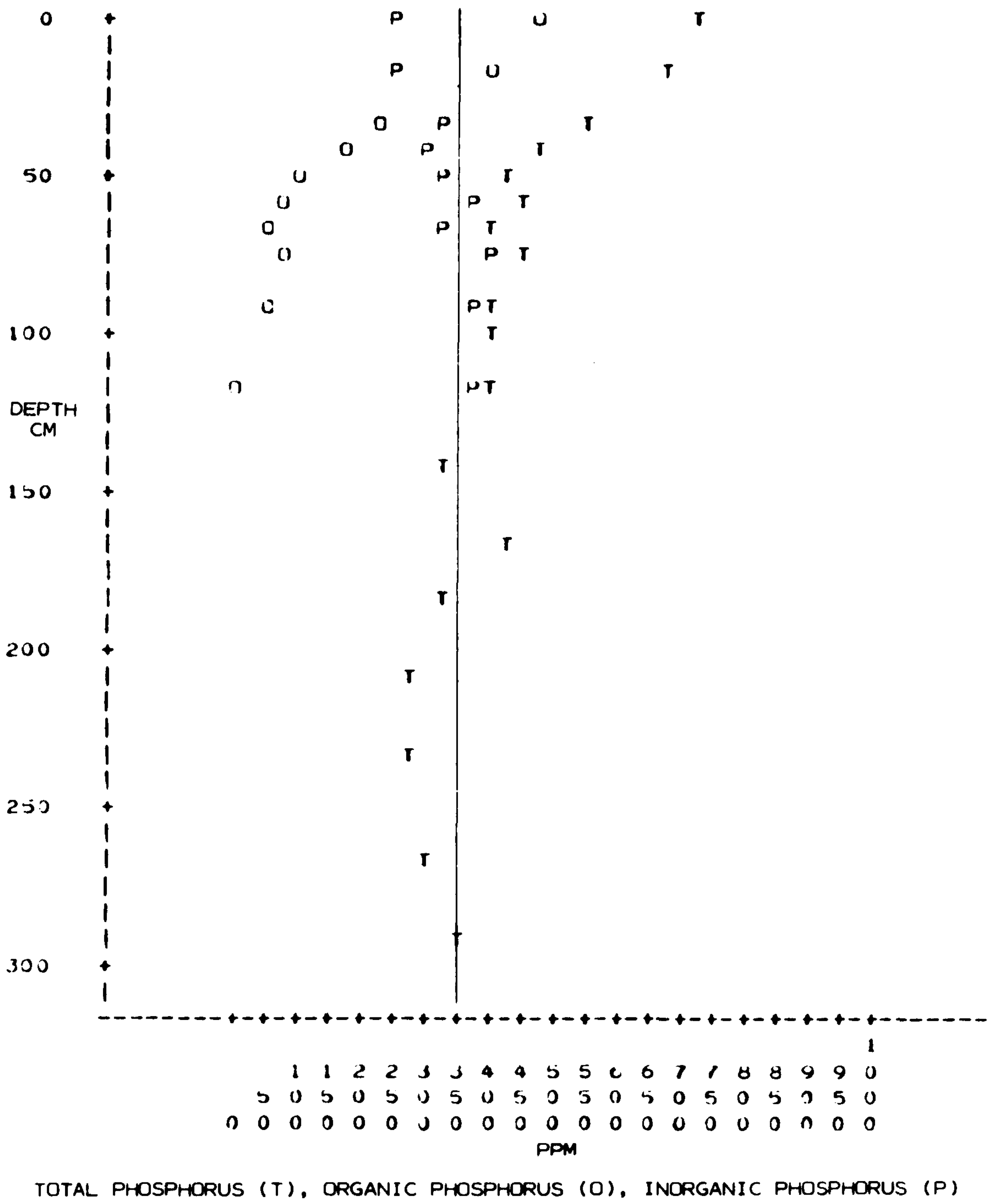


Figure 53. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Harps in undrained traverse

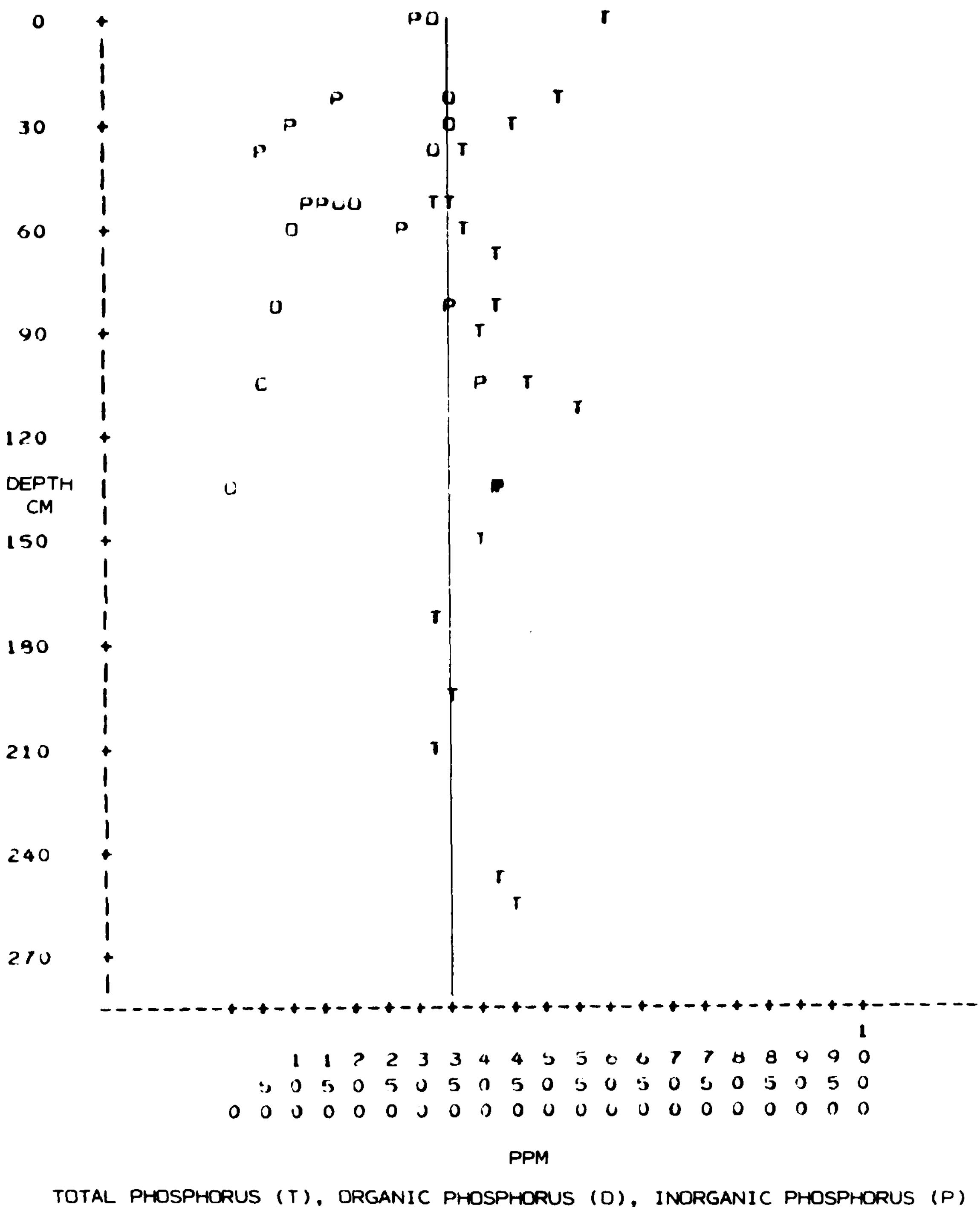


Figure 54. Distribution of total phosphorus, organic phosphorus, and inorganic phosphorus with depth for Okoboji in undrained traverse

is more weathered; this is inferred from a more severe minimum total phosphorus and more definite maximum total phosphorus distribution pattern.

Total phosphorus for Clarion in the tile drained traverse (Figure 43) decreased from 313 ppm at 20 cm to a minimum of 244 ppm at 63 cm. This is a total phosphorus decrease of 69 ppm. From 63 to 74 cm, total phosphorus increased to 333 ppm, gradually decreased to 304 ppm at 100 cm, increased to about 350 ppm at 110 cm, and then remained almost constant at 350 ppm down to 295 cm.

Total phosphorus distribution for Clarion in the undrained traverse (Figure 49) was similar to total phosphorus distribution for Clarion in the drained traverse except for two differences. First, there was a more severe minimum of total phosphorus, 202 ppm, at 77 cm. This was a 163 ppm decrease in total phosphorus from the 20 to 77 cm zone. Second, total phosphorus increased 220 ppm from 77 cm to 110 cm. This increase was not evident in the drained Clarion.

Total phosphorus distribution for Nicollet in tile drained and undrained traverses

Figure 44 shows that total phosphorus in the tile drained Nicollet decreased from 457 ppm at 20 cm to 233 ppm at 136 cm. A "not very definite" total phosphorus minimum occurred at 84 cm. Below 136 cm, total phosphorus increased to 450 ppm at 195 cm then decreased to 325 ppm at 210 cm. Particle size data (Appendix D) showed no changes in relative proportions of sand, silt, or clay that relate to these vertical changes in total phosphorus.

A more characteristic total phosphorus distribution curve was shown for Nicollet in the undrained traverse (Figure 50). A definite, more severe minimum of total phosphorus occurred at 60 cm. There was a decrease in total phosphorus of 155 ppm in the 20 to 60 cm zone. Below 60 cm, total phosphorus increased to 398 ppm at 90 cm, decreased to 365 ppm at 95 cm, and remained constant at about 365 ppm to 300 cm.

These total phosphorus distribution curves suggested that Nicollet in the tile drained traverse is more weathered than Nicollet in the undrained traverse. It appears that the first minimum total phosphorus peak in the tile drained Nicollet was related to phosphorus eluviation during soil formation. The second minimum peak at 140 cm and lower maximum total phosphorus peak at 190 cm apparently was related to tile drainage: A tile drain located at the lower end of this traverse would result in water dissolved phosphorus moving through the soil at a faster rate than in the non-tiled traverse. The tile would tend to move free water, or water held at tensions of approximately 1/3 bar or less, out of the system. Nicollet in the undrained traverse was unable to remove excess water as fast and this resulted in less total phosphorus movement.

Total phosphorus distribution for Webster in tile drained and undrained traverses

A comparison of total phosphorus in the tile drained Webster and undrained Webster (Figures 45 and 51, respectively) showed more variability in total phosphorus distribution in the tile drained Webster. For example, an increase in total phosphorus of 117 ppm from 37 to 47 cm is shown is Figure 45. There is also a small increase in total phosphorus at 94 and 117 cm. Neither of these small peaks were present in the undrained Webster.

There was a decrease in total phosphorus of 156 ppm from 117 to 155 cm in the tile drained Webster. This minimum total phosphorus peak was not evident in the undrained Webster. These more definite minimum and maximum total phosphorus peaks that were evident in the tile drained Webster and not evident in the undrained Webster are related to differences in water table fluctuations, rates of water movement, and texture.

A tile drain installed 120 cm below the soil surface at the lowest hillslope position (Okoboji) would create an artificial water table surface. A build-up of total phosphorus could occur at the surface of this water table. Since installation of this tile, it appears that some total phosphorus has accumulated at 95 cm in Webster of the tile drained traverse.

Data in Appendix D for the tile drained Webster showed a total sand increase of nearly 45% from 100 to 140 cm. This zone had a decrease in total phosphorus of 156 ppm. A high sand content and associated large proportion of macropores would promote lateral downslope movement of water.

Total phosphorus distribution for Canisteo in tile drained and undrained traverses

A comparison of total phosphorus distribution with depth between Canisteo in the drained and Canisteo in the undrained traverse (Figures 46 and 52, respectively) showed there was a more severe minimum and maximum total phosphorus peak for Canisteo in the tile drained traverse.

For example, total phosphorus decreased from 658 ppm at 25 cm to 287 ppm at 70 cm, then increased to 666 ppm at 198 cm. The 379 ppm increase in total phosphorus from 70 cm to 198 cm suggested eluviation of total phosphorus from the 50 to 100 cm depth and subsequent illuviation of total phosphorus at 100 to 270 cm. Accumulation of total phosphorus due to underground lateral movement of water from upslope was also suggested as part of the reason for a 379 ppm total phosphorus increase.

The total phosphorus distribution curve for Canisteo in the undrained traverse showed two total phosphorus minimums. The first minimum occurred at 50 cm while the second minimum occurred at 125 cm. The upper minimum was due to plant uptake while the lower minimum was probably related to high total sand content (Appendix D). Some loss of total phosphorus at the 125 cm depth was probably due to underground lateral movement of water.

Total phosphorus distribution for Harps in tile drained and undrained traverses

Distribution of total phosphorus from 20 cm to 100 cm was similar for Harps in drained and undrained traverses (Figures 47 and 53, respectively). Below 100 cm, distribution of total phosphorus was not similar. A maximum peak in total phosphorus of 420 ppm occurred in a zone from 167 to 200 cm for Harps in the drained traverse. Reasons for more variability in vertical distribution of total phosphorus for Harps in the drained traverse as compared to Harps in the undrained traverse may be related to differences in water movement caused by an artificial tile drain.

Total phosphorus distribution for Okoboji in tile drained and undrained traverses

Total phosphorus distribution for Okoboji in the tile drained traverse (Figure 48) showed that total phosphorus decreased 330 ppm from 20 to 60 cm, then gradually increased to a maximum of 473 ppm at 168 cm. No large increase in total phosphorus as was shown for Canisteo or Harps in the tile drained traverse was evident for Okoboji in the tile drained traverse. Eluviation of total phosphorus above 120 cm was probably responsible for the increased phosphorus at 140 to 200 cm. Lateral underground movement of water from upslope probably added some additional phosphorus in the 120 to 200 cm zone.

Figure 54 shows that Okoboji in the undrained traverse had phosphorus minimums and maximums. The maximum peak at 120 cm was associated with illuviation of phosphorus in an area of high $CaCO_3$.

Trends of total phosphorus from Clarion to Okoboji in tile drained and undrained traverses

Weighted mean total phosphorus of A horizon, B horizon, sola, and 20 to 100 cm zones are given in Figures 55 and 56 for all soils in tile drained and undrained traverses, respectively. Total phosphorus of Ap horizons was excluded from all calculations.

Almost all fractions of total phosphorus increased from Clarion to Okoboji in both tile drained and undrained traverses.

A comparison of the weighted mean total phosphorus between all soils in tile drained and undrained traverses at 20 to 100 cm, showed slightly more total phosphorus for soils of the tile drained traverse. For

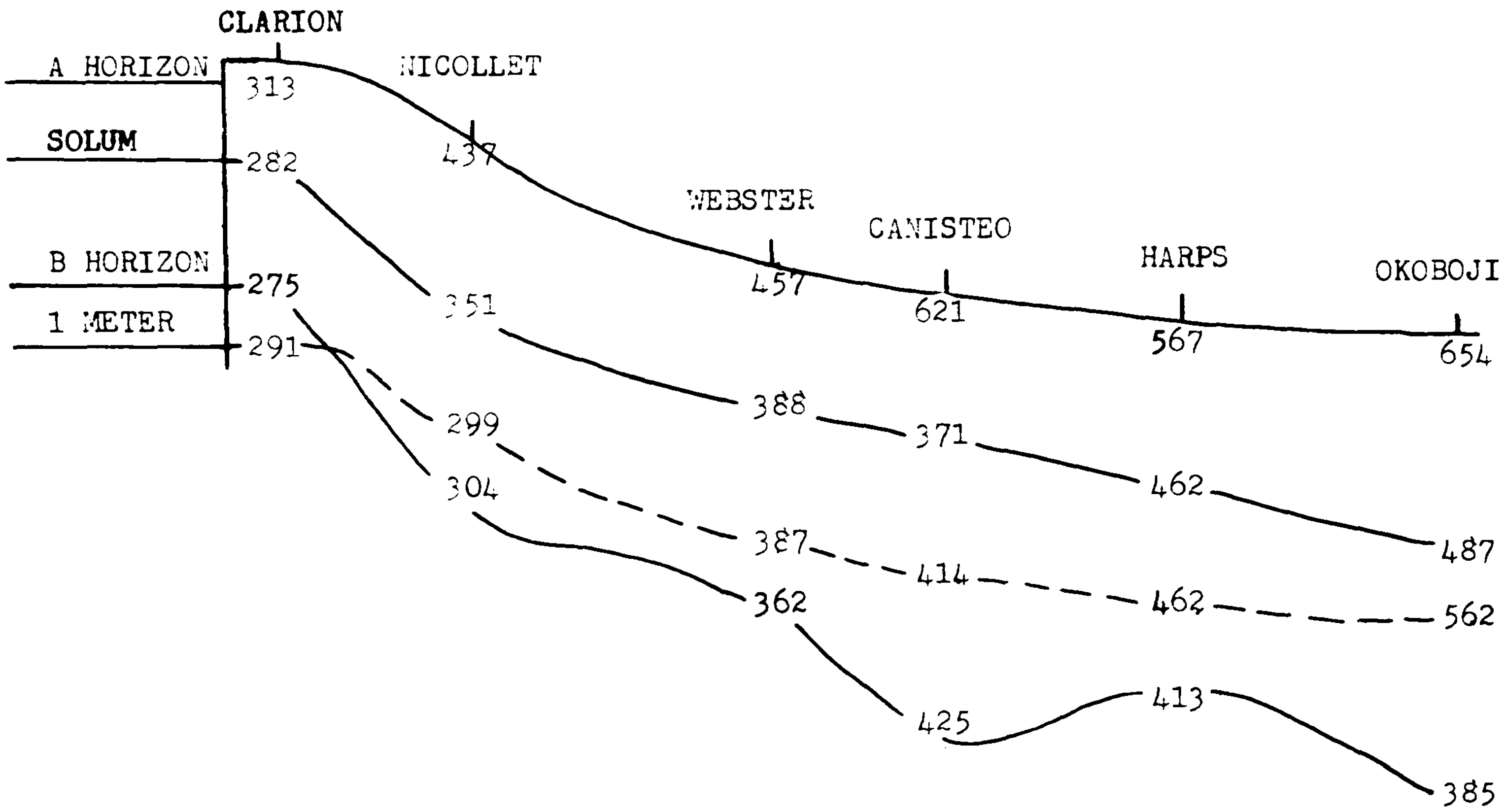


Figure 55. Distribution of weighted mean total phosphorus (ppm) of A horizons, sola, B horizons, and 1 meter depth for all soils in the tile drained traverse.

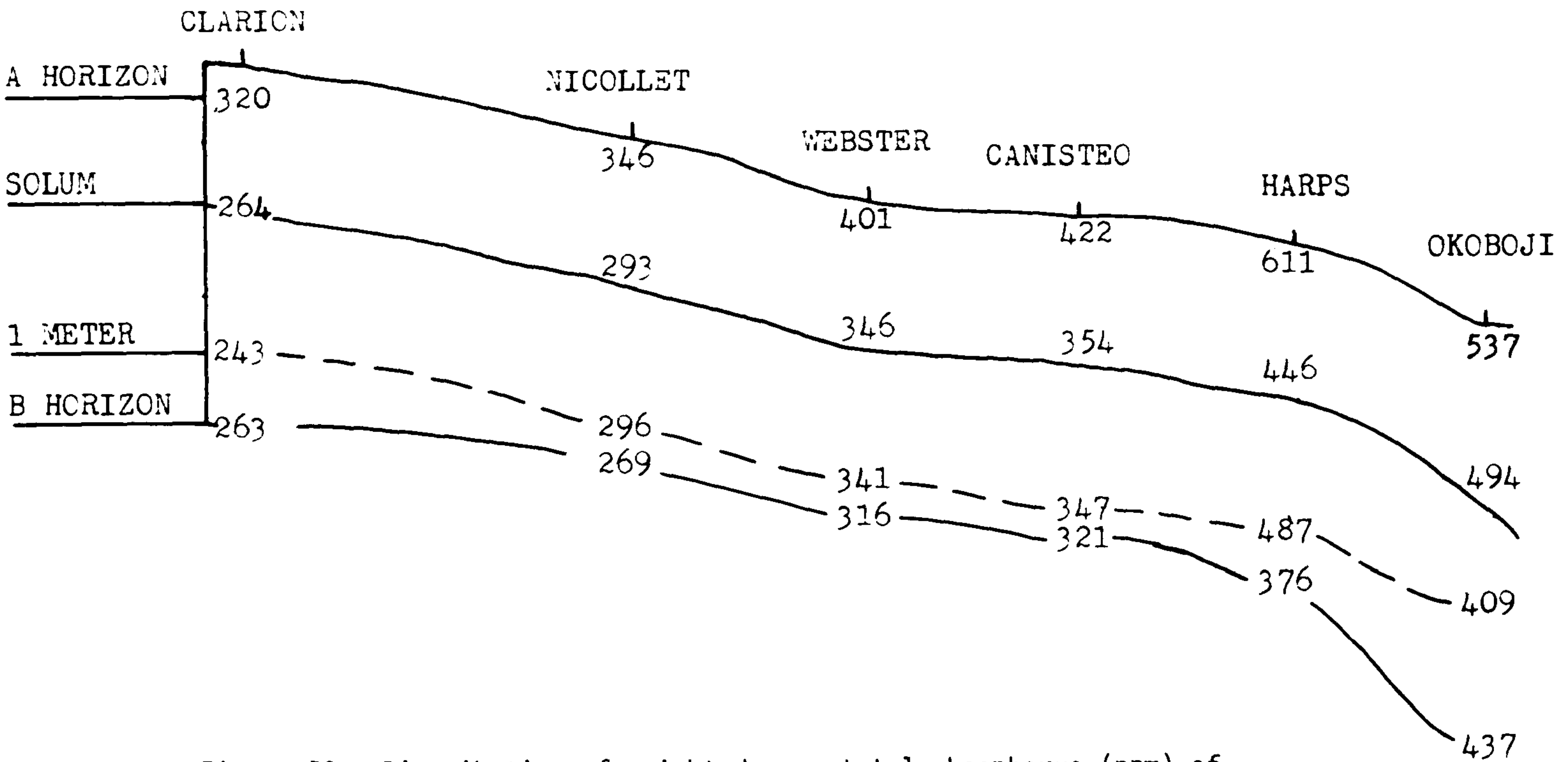


Figure 56. Distribution of weighted mean total phosphorus (ppm) of A horizons, sola, B horizons, and 1 meter depth for all soils in the undrained traverse.

example, the Clarion in the tile drained traverse had 48 ppm more total phosphorus than the Clarion in the undrained traverse. Webster and Okoboji in the tile drained traverse also had more total phosphorus than Webster or Okoboji in the undrained traverse.

Distribution of organic phosphorus for all soils in tile drained and undrained traverses

Organic phosphorus data are presented in Appendix D. Distribution of organic phosphorus for all soils of the tile drained and undrained traverses is presented in Figures 43 through 48, and 49 through 54, respectively. Organic phosphorus for Ap horizons is excluded from the following discussion.

Tile drained traverse Distribution of organic phosphorus for Clarion in the tile drained traverse is shown in Figure 43. Organic phosphorus decreased from 192 ppm at 20 cm to 6 ppm at 115 cm. Organic phosphorus increased with increasing distance from the Clarion site. For example, an organic phosphorus content of 414 ppm at 20 cm in Webster decreased to 9 ppm at 170 cm. A 542 ppm organic phosphorus content at 20 cm in Okoboji decreased to 7 ppm at 142 cm.

Undrained traverse Organic phosphorus distribution for soils in the undrained traverse was not as systematic as for soils in the tile drained traverse. Comparison of Figures 43 and 49 shows distribution of organic phosphorus in the tile drained and undrained Clarion to be similar. Organic phosphorus did not increase from Clarion to Okoboji in this undrained traverse as was shown in the tile drained traverse. For example, in comparing 20 to 31 cm zones, organic phosphorus in the

Clarion was 365 ppm, Webster contained 320 ppm, and Okoboji contained 341 ppm.

The systematic increase of organic phosphorus with decreasing slope in the tile drained traverse and non-systematic pattern of organic phosphorus distribution with depth in the undrained traverse may be related to differences in water tables caused by tile drained vs. undrained systems. Sola for soils in the tile drained traverse were saturated for shorter periods of time while sola for soils in the undrained traverse were saturated for longer periods of time.

Organic Carbon and pH

Organic carbon data for all soils in tile drained and undrained traverses are given in Appendix D. Plots of organic carbon with depth for these soils are shown in Figures 57 through 68.

Organic carbon content in the A horizon increased from Clarion to Okoboji in both tile drained and undrained traverses. For example, from 0 to 20 cm in the Clarion of the tile drained traverse, organic carbon was 2.0%, while from 0 to 20 cm in the Okoboji of the tile drained traverse, organic carbon was 5.7%.

Thickness of organic carbon accumulation increased from Clarion to Okoboji in both tile drained and undrained traverses. For example, surface soil with at least 1% organic carbon was 43 cm thick for Clarion in the undrained traverse while organic carbon content of 1% or more extended to a depth of 81 cm for Okoboji in the undrained traverse. This same pattern of accumulation of organic carbon with decreasing slope was

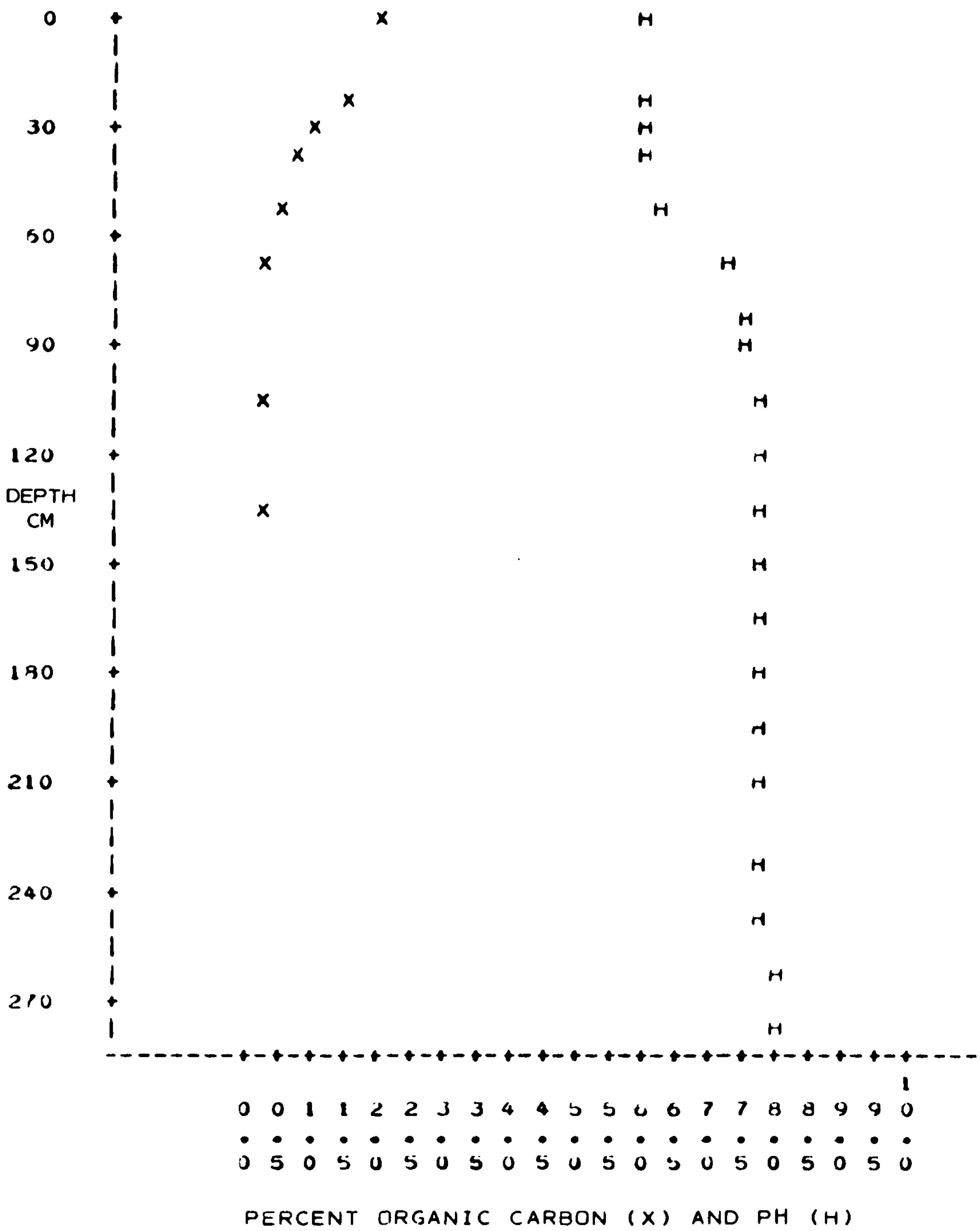


Figure 57. Distribution of pH and percent organic carbon with depth for Clarion in tile drained traverse

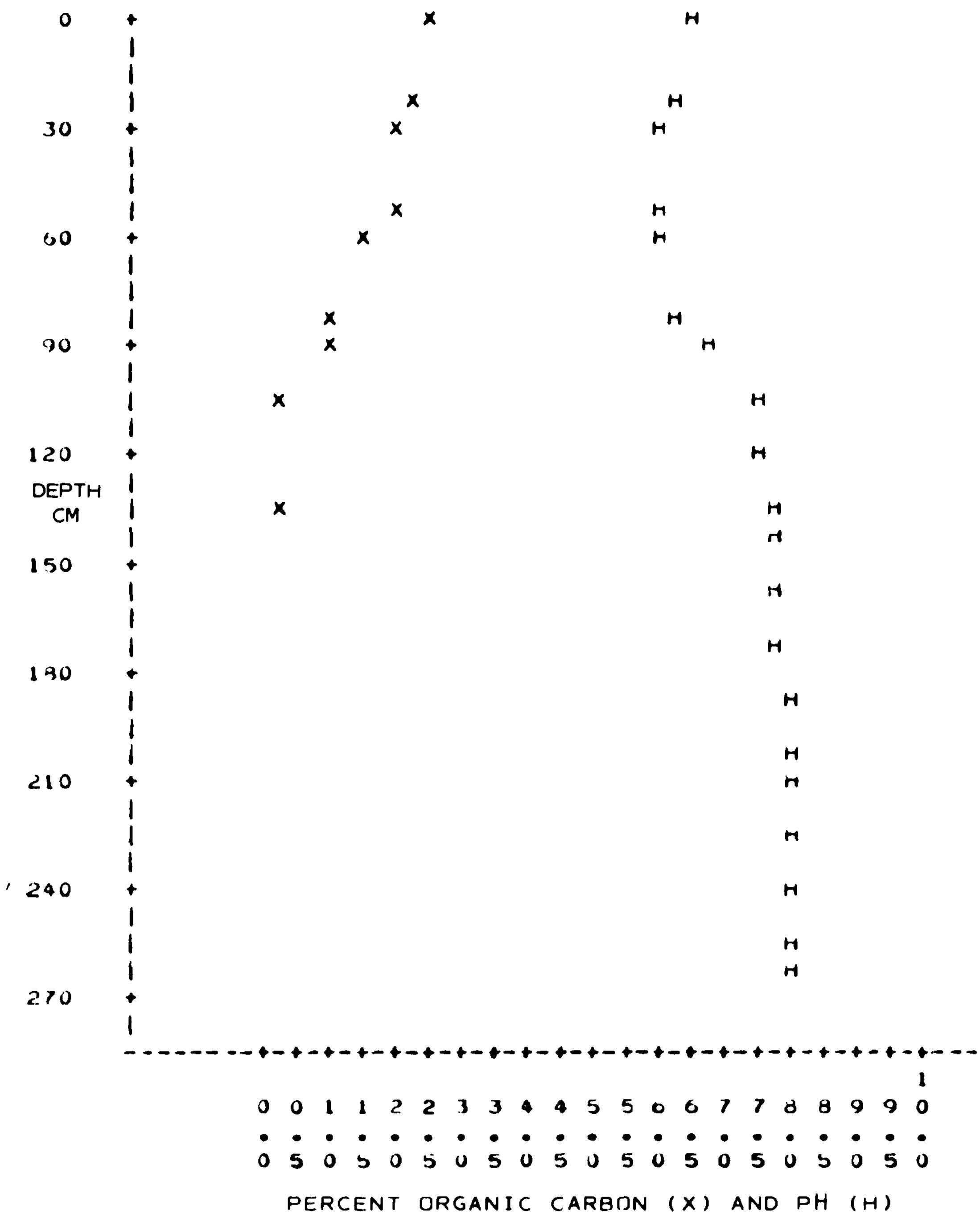


Figure 58. Distribution of pH and percent organic carbon with depth for Nicollet in tile drained traverse

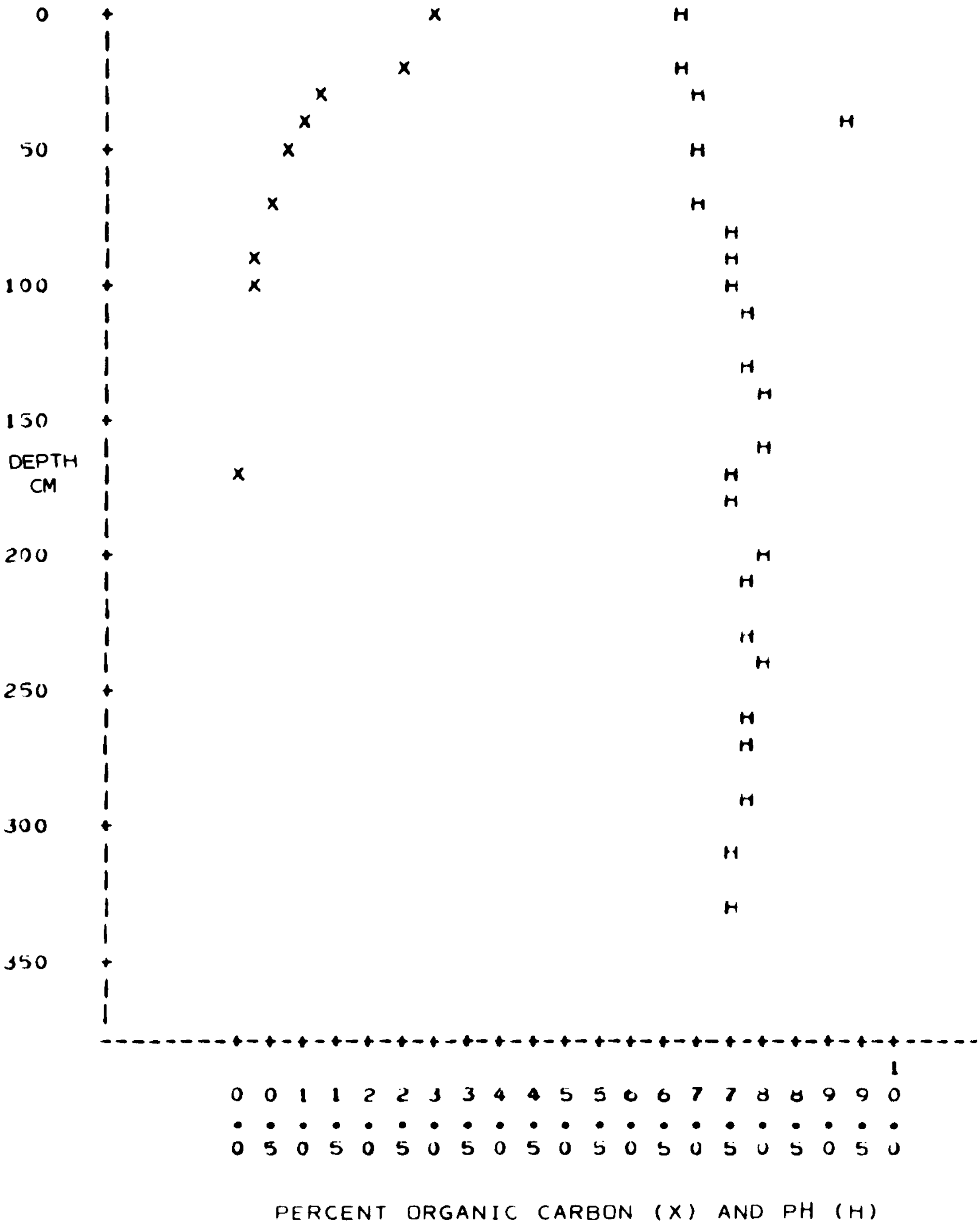


Figure 59. Distribution of pH and percent organic carbon with depth for Webster in tile drained traverse

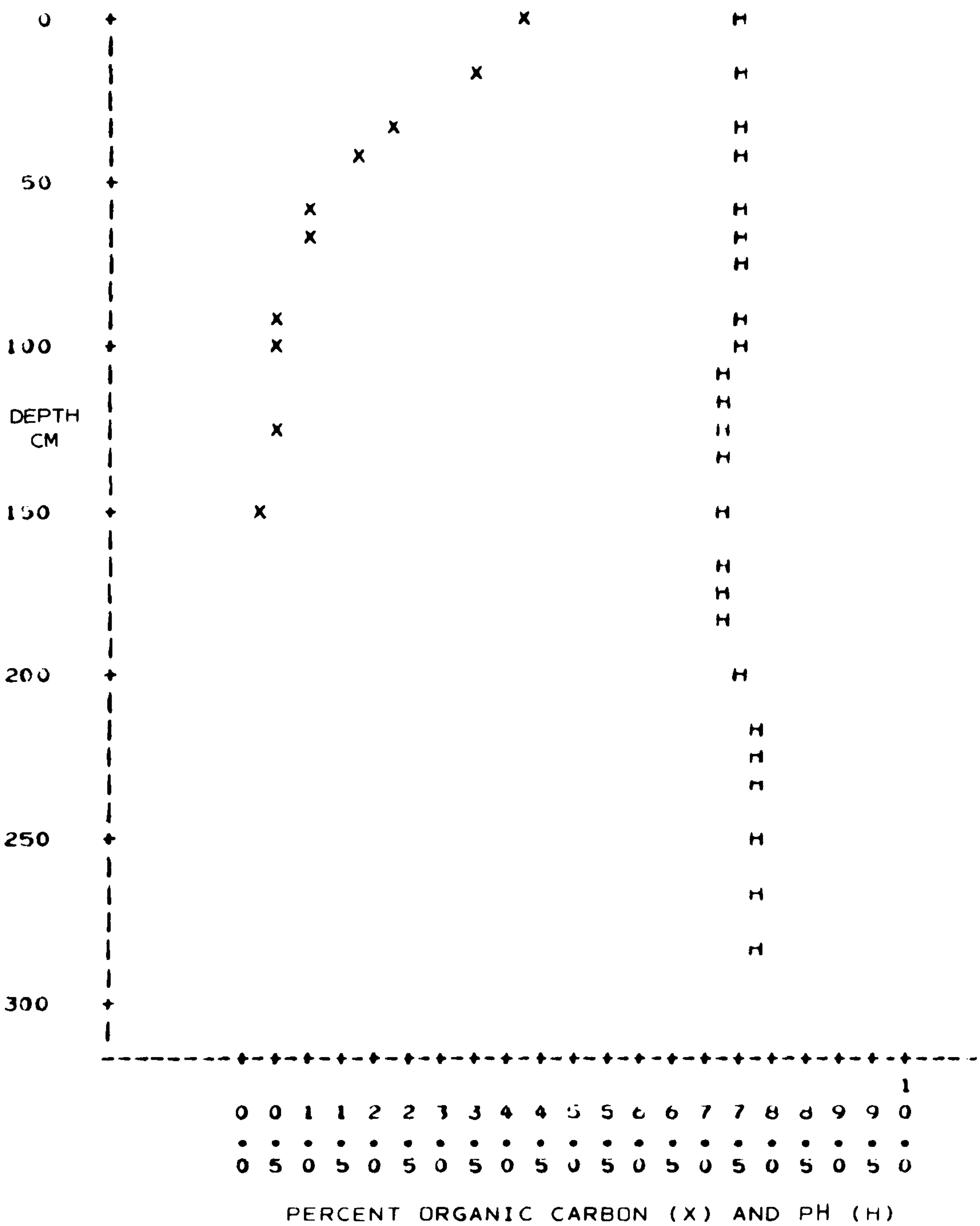


Figure 60. Distribution of pH and percent organic carbon with depth for Canisteo in tile drained traverse

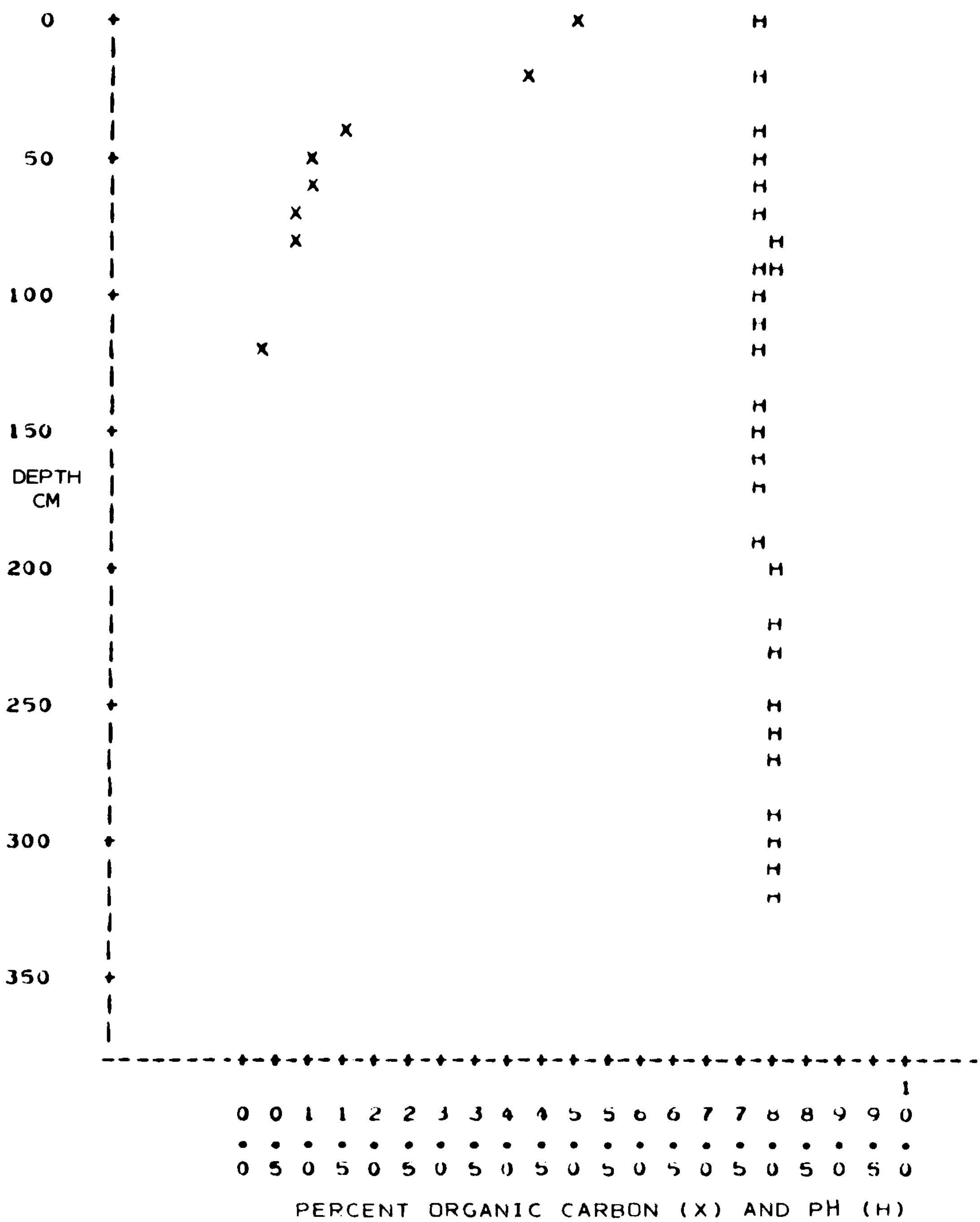


Figure 61. Distribution of pH and percent organic carbon with depth for Harps in tile drained traverse

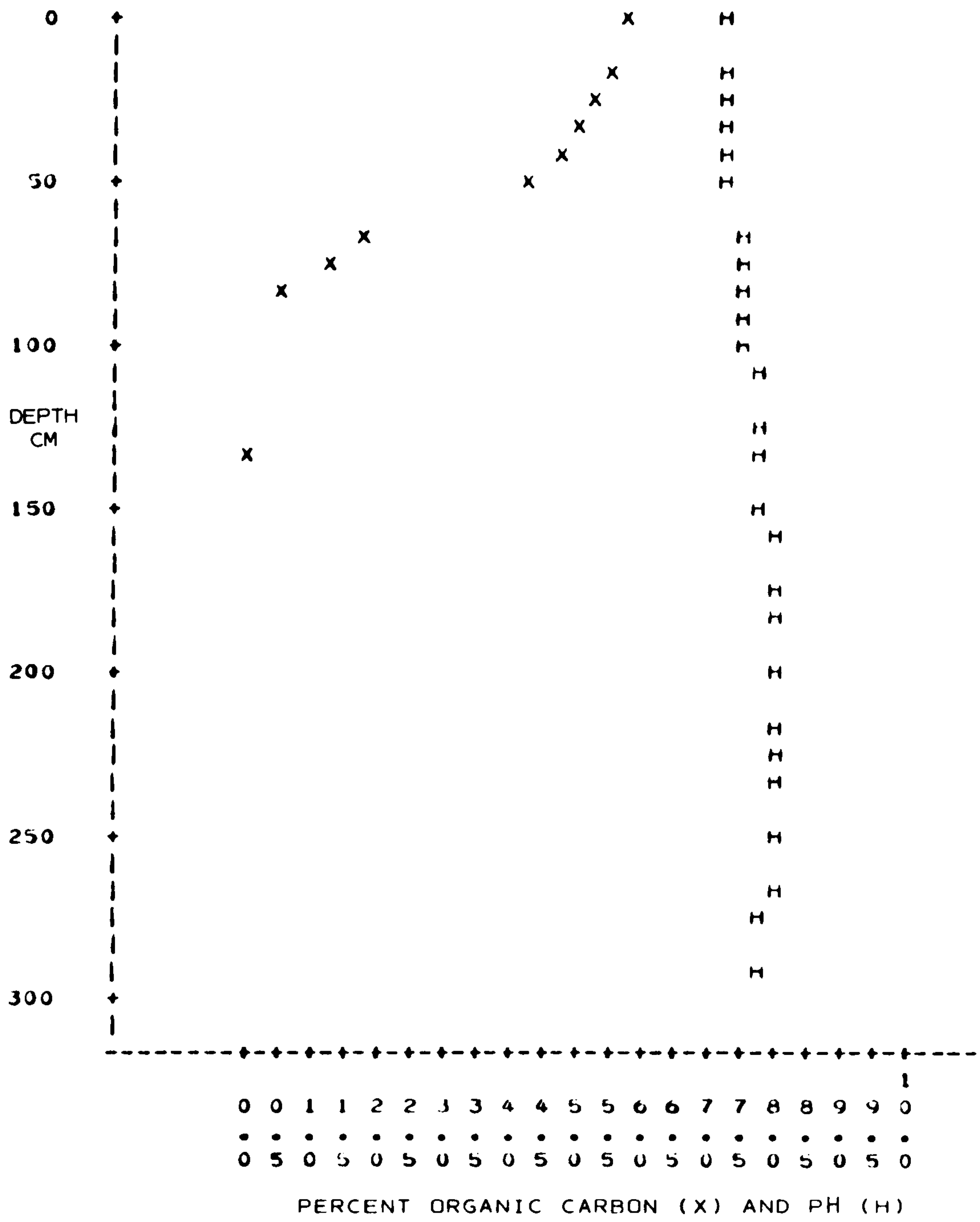


Figure 62. Distribution of pH and percent organic carbon with depth for Okoboji in tile drained traverse

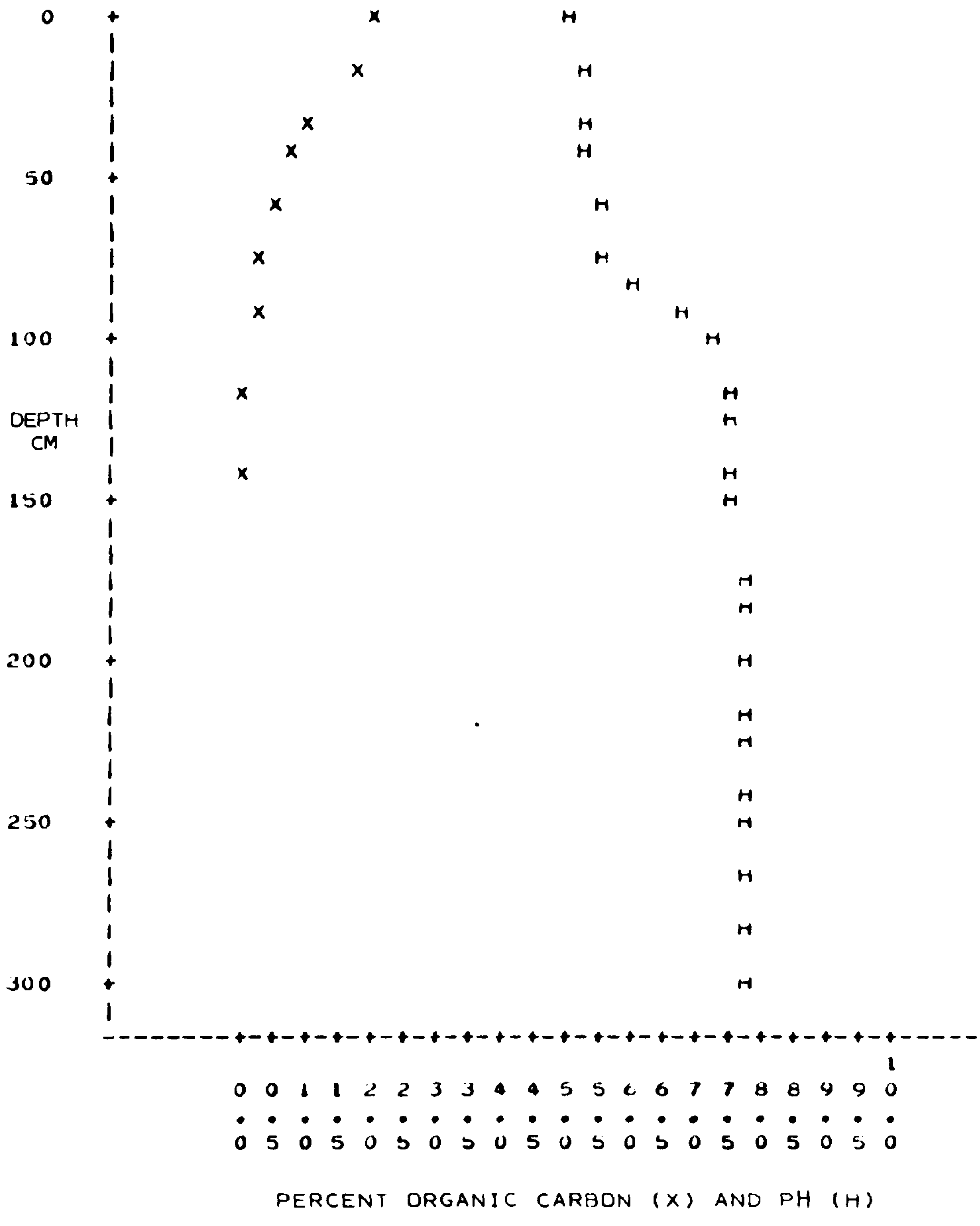


Figure 63. Distribution of pH and percent organic carbon with depth for Clarion in undrained traverse

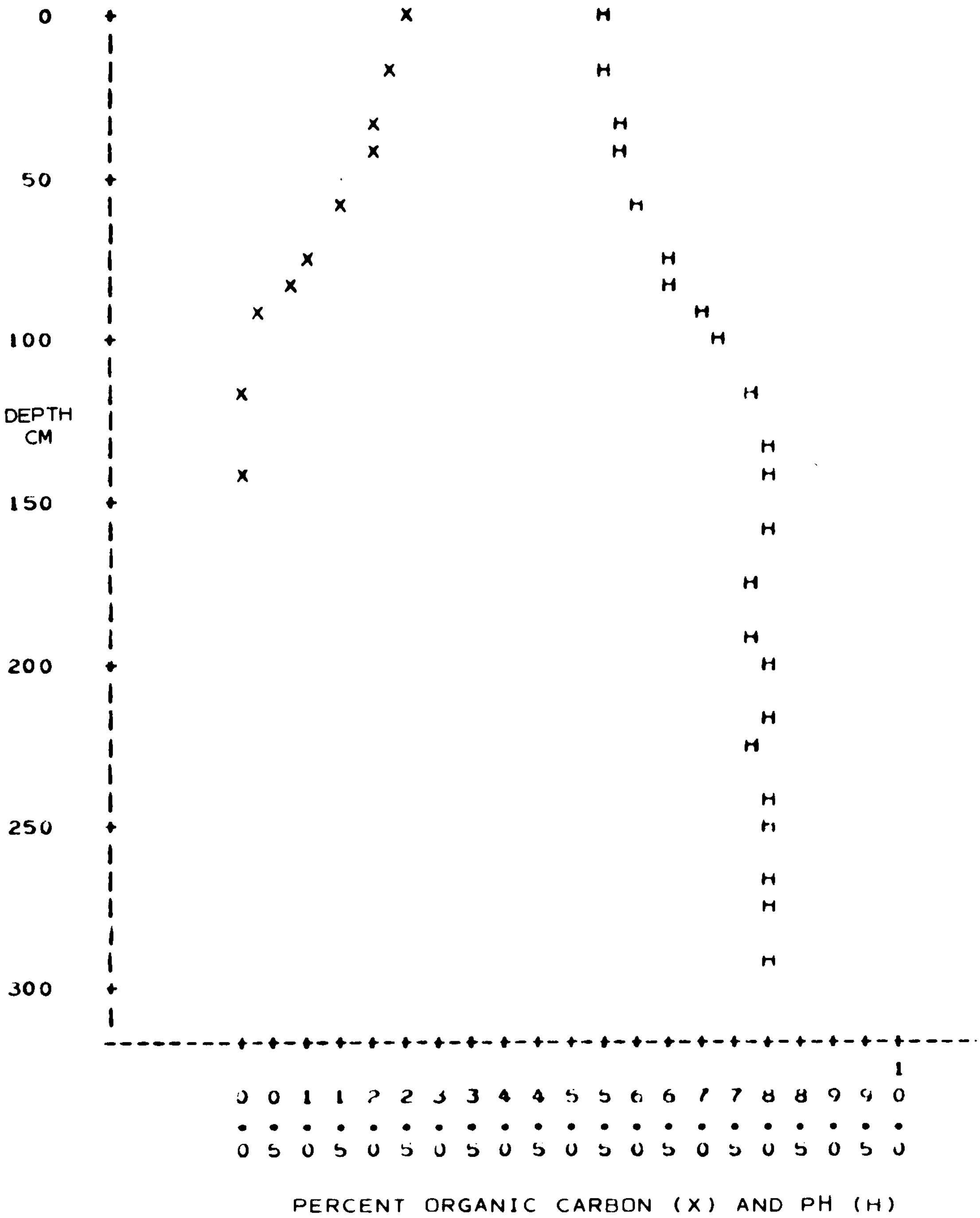


Figure 64. Distribution of pH and percent organic carbon with depth for Nicollet in undrained traverse

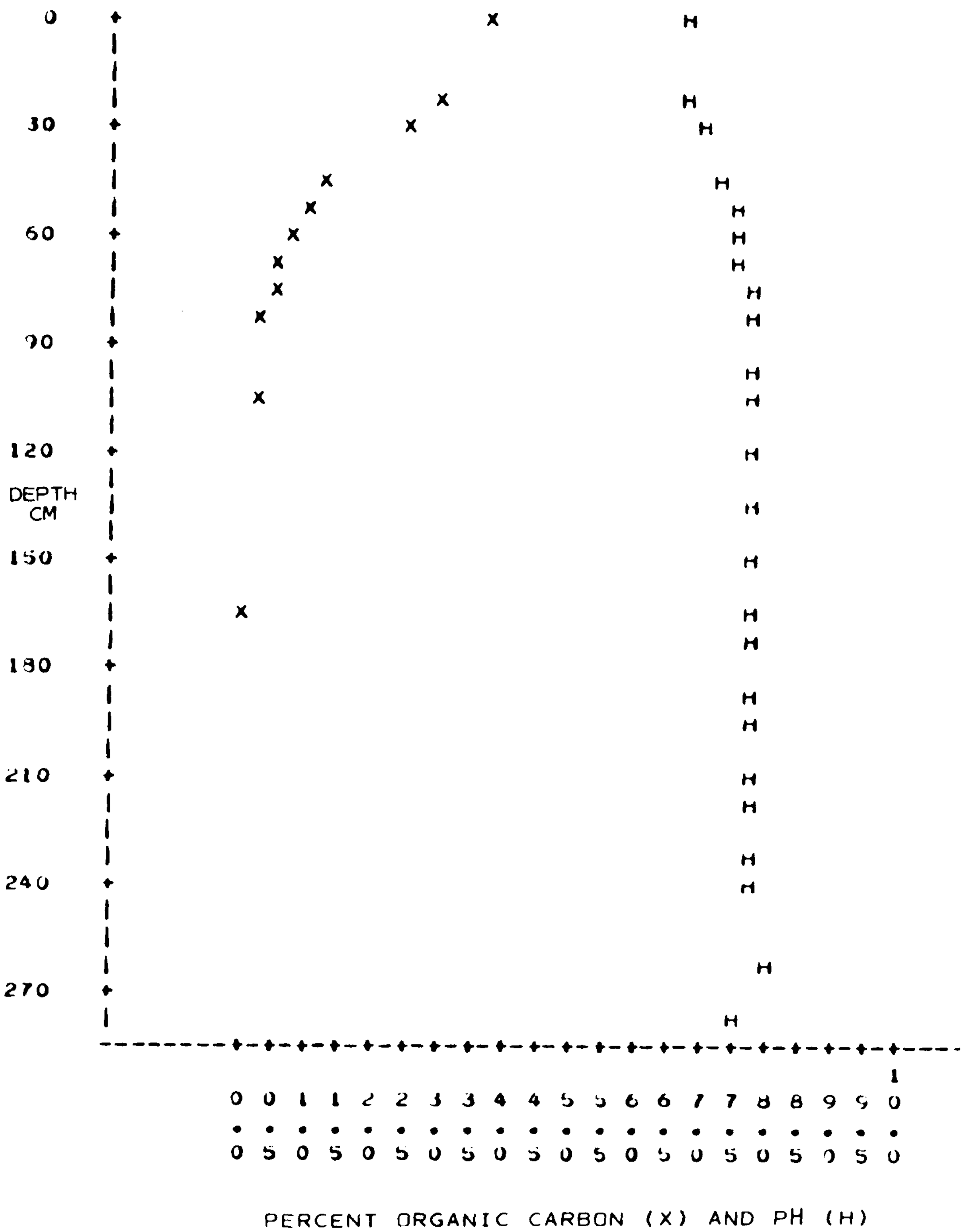


Figure 65. Distribution of pH and percent organic carbon with depth for Webster in undrained traverse

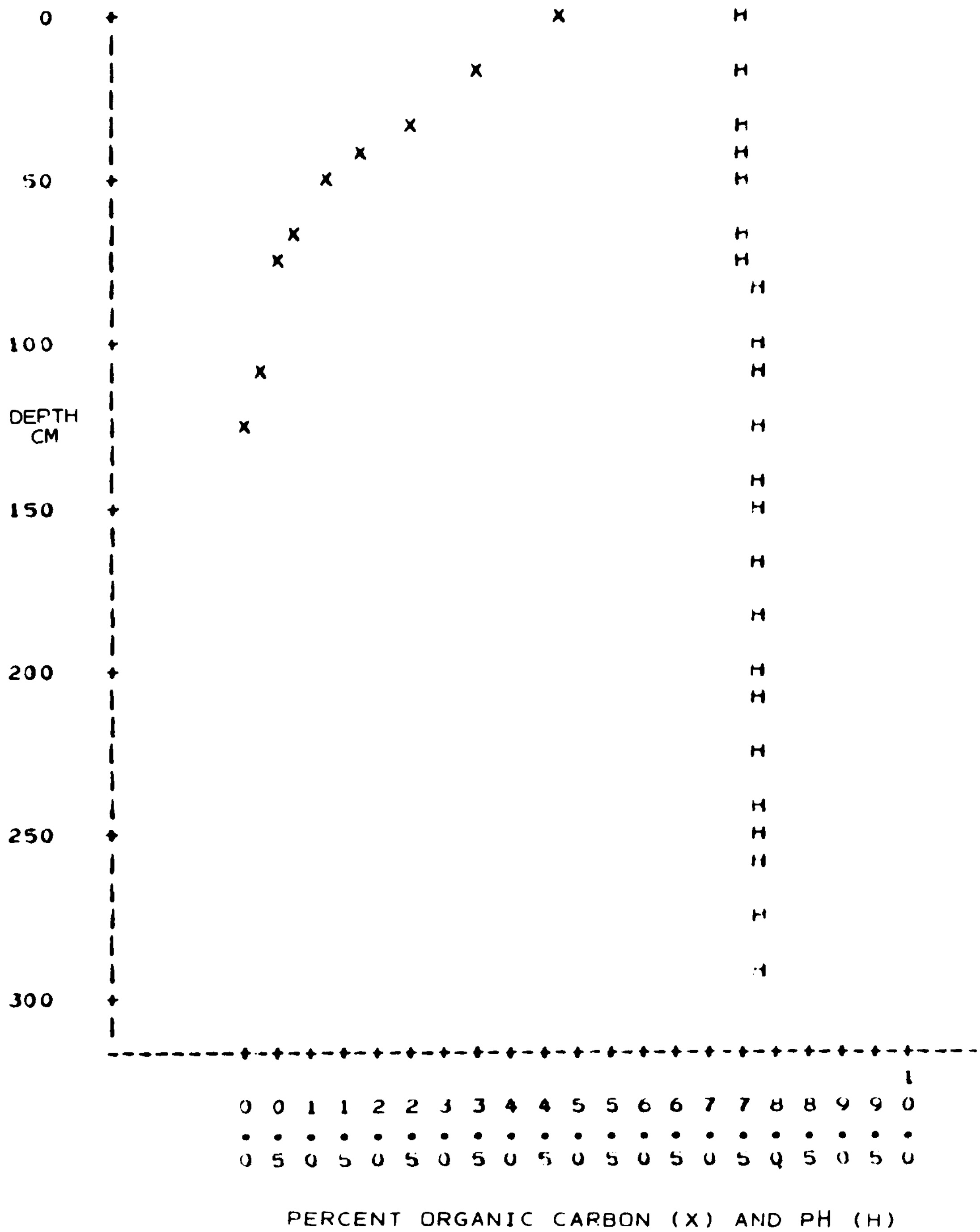


Figure 66. Distribution of pH and percent organic carbon with depth for Canisteo in undrained traverse

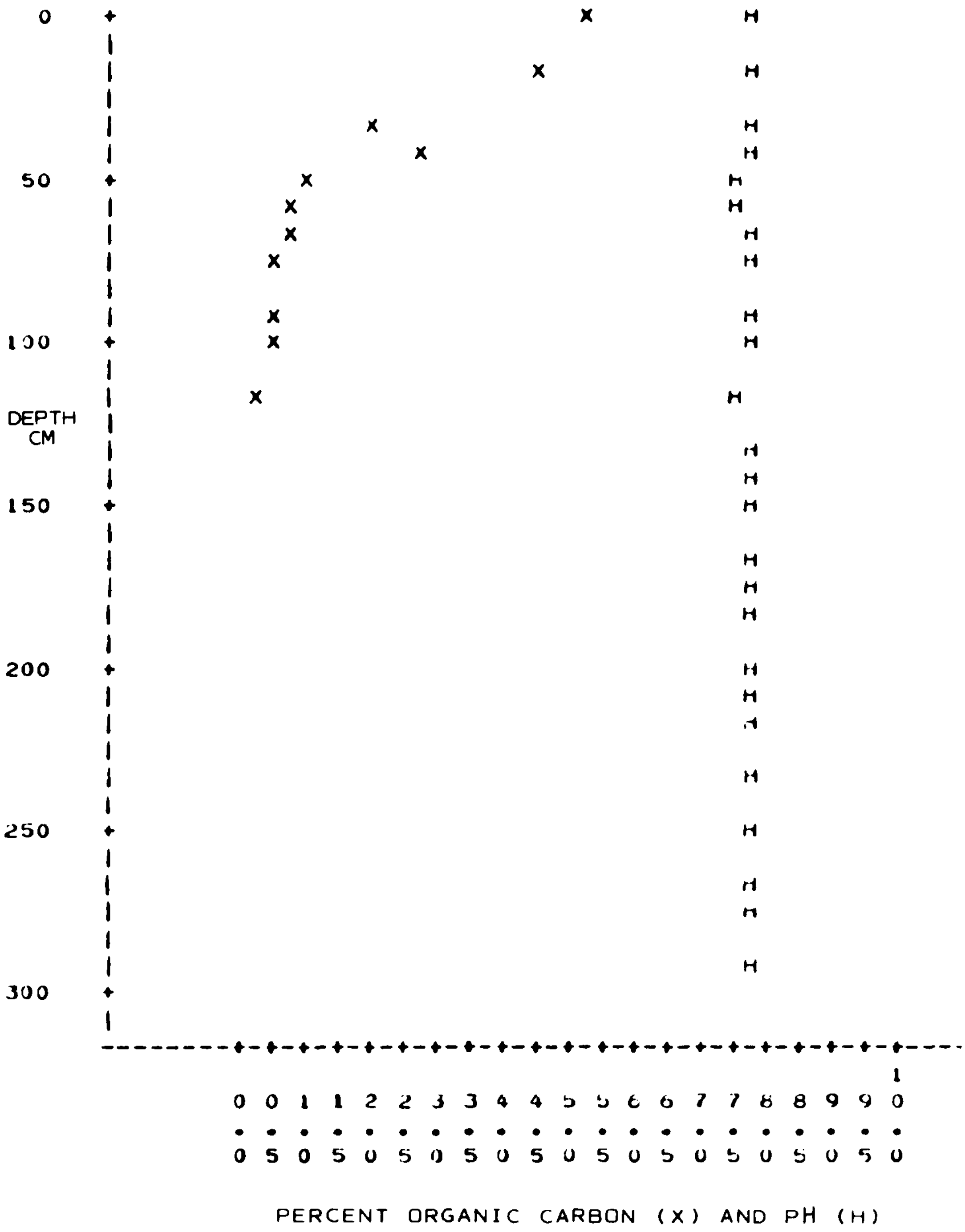


Figure 67. Distribution of pH and percent organic carbon with depth for Harps in undrained traverse

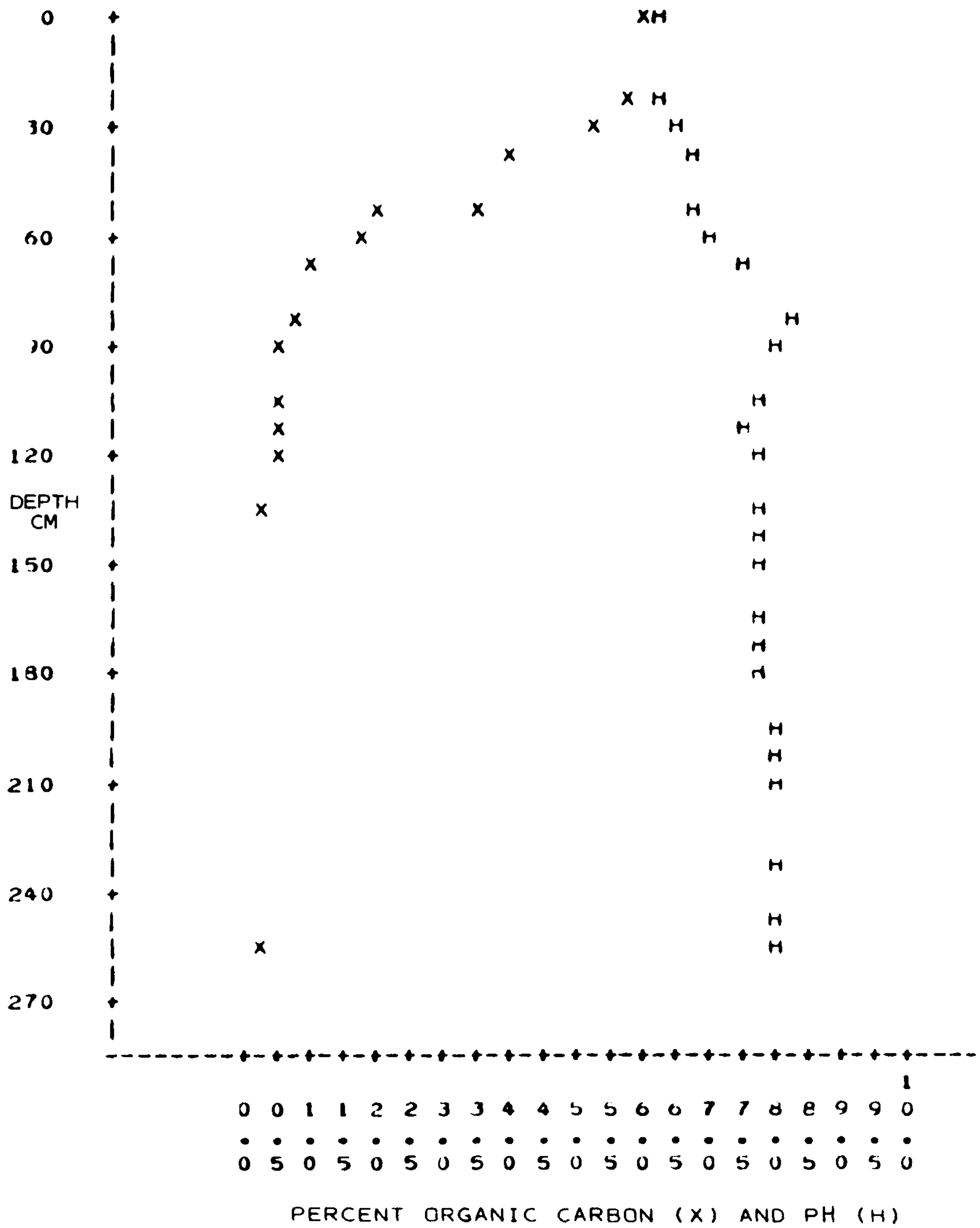


Figure 68. Distribution of pH and percent organic carbon with depth for Okoboji in undrained traverse

present for soils of the tile drained traverse.

There appeared to be a direct relationship between depth and duration of water tables and distribution of percent organic matter. Part I showed that depth to water tables was less and duration of water tables was longer for Nicollet through Okoboji soils in the undrained traverse than comparable soils in the tile drained traverse. Depth to water tables decreased and duration of water tables increased from higher to lower hillslope positions in both drained and undrained traverses. Therefore, rates of organic matter decomposition decreased from well drained to very poorly drained soils.

pH increased from Clarion to Harps, then decreased from Harps to Okoboji in both tile drained and undrained traverses (Appendix D). Depth to pH of 7.4 decreased from Clarion to Harps, then increased from Harps to Okoboji in both traverses. Comparable soils of both tile drained and undrained traverses had similar depth distributions of pH. For example, Figures 57 and 63 showed that Clarion in tile drained and undrained traverses had similar pH distributions with depth. Depth distribution of pH for all soils in tile drained and undrained traverses is illustrated in Figures 57 through 68.

SUMMARY AND CONCLUSIONS

One representative artificially tile drained and one representative undrained Clarion toposequence were selected in Story County, Iowa. Each traverse contained a Clarion - Typic Hapludoll, Nicollet - Aquic Hapludoll, Webster - Typic Haplaquoll, Canisteo - Calcic Haplaquoll, Harps - Typic Calciaquoll, and Okoboji - Cumulic Haplaquoll soil series. Chemical properties of clay, phosphorus, organic carbon, and pH were selected to determine if there were differences between soils of drained and undrained traverses.

Soil cores were collected at each site within each traverse. Detailed soil profile descriptions were completed for each soil. Soil horizons were ground with a mortar and pestle and passed through a 2mm sieve. Particle size analyses and pH determinations were made on the 2mm soil samples. Soil horizon subsamples were collected from the 2mm horizon samples and ground with a mortar and pestle to pass a 100 mesh sieve. These finely ground subsamples were used for organic carbon, iron, and phosphorus determinations.

Finer textured materials above the original till, concentration of finer textured material with decreasing slope, and increasing thickness of finer textured surficial sediment with decreasing slope indicated that tile drained and undrained traverses were characterized by a systematic system of erosion and deposition. Both traverses appeared to fit into the erosional and depositional model of Walker (1965).

Differences in particle size distribution were found between comparable soil series in tile drained and undrained traverses. For example, sola of Clarion in the undrained traverse contained 4% more clay than sola of Clarion in the tile drained traverse. This difference may be related to differences in weathering environments between these two sola caused by perching of water above strata high in sand. The other and more acceptable explanation relates to variability of material.

Sola of Nicollet, Webster, Canisteo, and Okoboji in the tile drained traverse contained from 4 to 10% more clay in their sola than comparable sola for these soils in the undrained traverse. Two possible hypotheses are proposed to account for these differences. First, clay differences may be related to differences in weathering environments of these soils. Differences could be caused by differences in degree of equilibrium and length of time it takes a chemical weathering environment to achieve quasi-equilibrium. A tile drained system would remove soluble weathering products at a faster rate than an undrained closed system. Faster non-equilibrium and faster weathering reactions would be associated with a tile drained system. In an undrained system where weathering products can not be leached out, a quasi-equilibrium is established quickly. The net result would be less clay formation in sola of Nicollet through Okoboji in the undrained traverse.

Second, differences in percent clay in sola of Nicollet, Webster, Canisteo, and Harps of the tile drained traverse may be caused by textural variations within the surficial sediment.

Rates of clay formation that could occur under even the most intensive weathering conditions during a period of 80 to 100 years still could not account for a 3% clay increase; therefore, the first hypothesis seems illogical. Tiling could contribute to faster rates of clay formation and translocation.

Weighted mean total phosphorus of A and B horizons, sola, and one meter zone increased with decreasing depth in both tile drained and undrained traverses. Soils in the tile drained traverse contained slightly more total phosphorus than comparable soils in the undrained traverse. These differences in total phosphorus are assumed to be caused from variability of surficial material.

Organic phosphorus and organic carbon increased with decreasing slope in both tile drained and undrained traverses. Differences in organic phosphorus and organic carbon were observed between comparable soils of tile drained and undrained traverses. These differences were caused because of differences and variability of surficial material. Eighty to 100 years of tiling may be related to incipient changes in organic phosphorus and organic carbon between comparable soils of drained and undrained traverses.

No differences in pH were detected between comparable soils of tile drained and undrained traverses.

PART III. USE OF ELECTRODE POTENTIALS TO ESTIMATE WEATHERING ENVIRONMENTS BETWEEN TILE DRAINED AND UNDRAINED CLARION TOPOSEQUENCES

INTRODUCTION

The acceptance of electrons by a molecule or ion from another molecule or ion is basic to soil systems. These oxidation and reduction reactions provide energy for organisms. Soil plays an important role in these electron transfer processes. For example, oxygen accepts electrons during oxidation of the carbohydrate molecule. Therefore, the amount and rate of oxidation of soil compounds such as organic matter is dependent on temperature and supply of electron acceptors.

Minerals and organic matter in soil have the ability to transfer electrons. This potential of a molecule or ion to either release or accept electrons can be measured by an electrode, thus the term electrode potential is used to describe the rate of these electron transfers. Oxygen determines the upper limit of electron transfers; in most cases hydrogen determines the lower limit of electron transfers. Water, composed of both oxygen and hydrogen, initiates the transfer of electrons in soils. The ability of a molecule or ion to accept an electron in soil is determined by the half reaction of

$$\frac{1}{2}\ O_2 + 2\ e^- + 2H^+ = H_2O \text{ (pH0 at } 25^oC\ Eh^o,\ 1.23V)$$

while the low electrode potential, lower limit or reduction in soil is determined by the half reaction of

$$2H^+ + 2\ e^- = H_2 \text{ (pH0 at } 25^oC\ Eh^o,\ 0V).$$

Most weathering processes in soil then occur between an electrode potential of 0 to 1.23V. Several of these chemical reactions have specific electrode potential. For example, ferrous iron formation occurs between electrode potentials of +300 to +400 mV. Other reactions, such as Mn^{+2} and HS^- formation, along with O_2 and NO_3^- depletion have specific electrode potential ranges.

Iron oxides and hydroxides together with organic matter are largely responsible for soil color. Iron, in either ferrous or ferric oxide form, has long been used in soil genesis investigations. Therefore, the ability to estimate internal soil conditions such as oxidation states of iron and other closely related soil elements seems invaluable in these studies.

In situ measurements of internal soil chemical environments via platinum electrodes in conjunction with a calomel reference electrode and voltmeter provide a way of estimating these weathering environments.

The purposes of this part of the study are:

1. To measure in situ electrode potentials in Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji in both drained and undrained traverses during a period of one year,
2. To determine the effect of water tables on electrode potential among and between individual members of both traverses,
3. To compare electrode potentials between individual members in undrained and artificially drained traverses,
4. To relate electrode potentials to soil morphological characteristics such as soil color and free iron content, and
5. To determine feasibility of using platinum electrodes to measure internal soil chemical weathering environments.

LITERATURE REVIEW

Any one of several basic chemistry texts such as Watt and Holmes (1958) defines oxidation as a loss of electrons and reduction as a gain of electrons. Thus, there is a transfer of electrons from one substance to another substance. Transfer only takes place when there are electron acceptors. When an ion loses an electron it becomes more positively charged and when an ion gains an electron it becomes more negatively charged.

Transfer of electrons from one substance to another results in varying oxidation states. All elements listed in the periodic table can have more than one oxidation state, that is, the number of electrons in extranuclear shells may be more or less than the number of protons in the nucleus. Thus, as already mentioned, negative and positive charged ions are created. Patrick (1960), Dirasian (1968), and Bohn et al. (1979) report that in biological and soil systems positive charges are transferred to hydrogen atoms which in turn can be lost from the system. This type of oxidation has long been known as dehydrogenation. On the other hand, a gain is called hydrogenation. Even though hydrogen is involved in nearly every electron transfer reaction, Bohn (1971) reports that oxidation-reduction reactions are governed by other factors.

Iron is an important element in soil and it has several oxidation states. These oxidation states result from either a loss or gain of electrons from electron orbits.

Patrick (1960) states that studying the relationship between soil and redox potential and associated concentrations of oxidized and reduced members has been difficult. Present state of the art techniques in controlling redox potential within a soil system during the duration of a given study leaves something to be desired. Black (1957) concurs that oxidation and reduction potential values are difficult to interpret. Bohn (1971) also reports that redox values in soil are difficult to determine and that because of the nature of soil, redox values vary widely over a distance of only a few millimeters. For example, ped exteriors may be aerobic; often adjacent interiors are anaerobic. Although electrode potential measurements have limitations, as yet there is no better way to study electron transfer reactions in soil systems. Therefore, until a better method is developed redox measuring techniques will be used.

Electrode potential as reported by Bohn (1971) is the electrochemical potential or electron availability of the electron at equilibrium. Electrode potential is symbolized by (Eh). At equilibrium, electrode potential is represented by Black (1957) as follows:

$$Eh = Eo - \frac{RT}{nF} \ln \frac{a_G^{\,g} \cdot a_H^{\,h} \ldots \text{(molor concentration of oxidants)}}{a_B^{\,b} \cdot a_C^{\,c} \quad \text{(molor concentration of reductants)}}$$

where a_B, a_C, a_G, etc. represent activities; Eh = oxidation-reduction potential relative to a standard hydrogen electrode. Eo = constant which is characteristic of a system where (oxidants) = (reductants) and Bohn et al. (1979) reports that Eo represents the redox couple's ability to donate or accept electrons at a standard condition and at equilibrium. R = 8.315 joules, T = absolute temperature, F = 96,500 coulombs and n =

number of electrons that are transferred in reaction, respectively.

Dirasian (1968) shows that at 25°C and when n is equal to unity the above equation becomes:

$$Eh = Eo = 0.0591 \log \frac{(\text{oxidants})}{(\text{reductants})}$$

Bohn et al. (1979) also states that at 25°C the standard Gibbs free energy equation is related to Eh^{o} by:

$$G^{o} = -nF\ Eh^{o} = -23.06\ n\ Eh^{o}$$

Several scientists including Bohn (1971) and Dirasian (1968) stress that the above Nernst equation assumes there is a thermodynamic equilibrium, but it has been shown that in biological systems a thermodynamic equilibrium seldom exists. In a steady state system, such as soil, electrons are continuously being released and transferred from one ion or substance to other ions or substances. Dirasian (1968) further states that since biological systems do not achieve thermodynamic equilibrium the potential developed should not be called oxidation-reduction potential but "Electrode Potential".

Several decades ago, researchers discovered that by substituting a noble metal such as platinum for the glass electrode in conjunction with a saturated calomel reference electrode and coupled to a potentiometer, electrode potential measurements in biological systems could be made. Black (1967) explains that if a platinum electrode is placed in a soil system, an electron potential characteristic to the soil solution will be imposed on the platinum electrode. There will be a measurable transfer of electrons from the soil solution to the platinum electrode.

In order to measure the rate of transfer of electrons, a saturated calomel electrode is inserted in the soil close to the platinum electrode. A voltage is created across the platinum and calomel electrode. A point where no current flows through the galvanometer, or when the flow of current between these two cells is equal, is determined. This amount of current is called the electrode potential.

The Nernst equation (Atkins, 1978) shows that it is possible to measure oxidation-reduction potentials from all elements, but it has been long recognized that only a few elements and associated electrode potentials are applicable to soil (Bohn et al., 1979). Thus, in soil systems the number of possible redox couples is narrow. The logic behind this has been explained by several researchers including Bohn et al. (1979). It is their consensus of opinion that the range of electrode potential is limited by the stability of water. If an oxidizing agent is contained in a solution, the resulting range of electrode potentials is controlled by the H_2O-O_2 couple. A half reaction of

$$\tfrac{1}{2}\, O_2 + 2e^- + 2H^+ = H_2O$$

determines the upper limit since water will tend to oxidize to O_2. Under natural soil conditions, O_2 is the strongest oxidizing agent that can be created. The lower limit of electrode potential in soil is usually determined by the half reaction of

$$2H^+ + 2e^- = H_2.$$

Several ions in soil act as the final electron acceptor. Dirasian (1968) states that in well-drained soils, molecular oxygen acts as a sink for electrons. Black (1957) states that every molecule of oxygen can accept up to four electrons. In this situation the maximum amount of energy is obtained from microbial activity. In anaerobic soil systems several compounds act as the final electron acceptor. Bohn et al. (1979) gives a step-by-step list of electron acceptors. This is contained in Table 21.

As shown in Table 21, oxygen is the strongest electron acceptor. In soils where oxygen is adequate, oxygen acts as the major oxidizing agent. It should also be pointed out that the higher the electrode potential the greater the amount of oxygen present in the system. Thus, there is a linear relationship between electrode potential and electron acceptance.

As the O_2 supply becomes insufficient, progressively weaker oxidation agents are utilized by soil microorganisms (Bohn et al., 1979). After all the oxygen has been used up, the next strongest electron acceptor is nitrate. After nitrate is reduced to N_2 or N_2O, Mn^{3+}, Mn^{4+} and Fe^{3+} are subsequently reduced. This creates a concentration of Fe^{2+} and Mn^{2+} ions. Sulfate is the next ion to be reduced to sulfur or sulfide. Finally, energy for microorganisms is taken from reduction of H^+ to H_2 contained in organic compounds. The lowest order of electron acceptors comes from fermenting of organic matter where some energy is released when CO_2, methane, or peat is formed.

So far all the attention has been given to electron acceptors. In order for electron transfer to take place, there must also be electron donors. Bohn et al. (1979) states that there are two major electron donors in soil. They are fresh plant material and soil organic matter.

Table 21. Order of utilization of principle electron acceptors in soils, equilibrium potentials of these half-reactions at pH 7, and measured potentials of these reactions in soils[a]

Reaction	Eh at pH 7(V)	Measured redox potentials in soils (V)
O_2 Disappearance		
$\frac{1}{2}\ O_2 + 2e^- + 2H^+ = H_2O$	0.82	0.6 to 0.4
NO_3^- Disappearance		
$NO_3^- + 2e^- + 2H^+ = NO_2^- + H_2O$	0.54	0.5 to 0.2
Mn^{2+} Formation		
$MnO_2 + 2e^- + 4H^+ = Mn^{2+} + 2H_2O$	0.4	0.4 to 0.2
Fe^{2+} Formation		
$FeOOH + e^- + 3H^+ = Fe^{2+} + 2H_2O$	0.17	0.3 to 0.1
HS^- Formation		
$SO_4{}^= + 9H^- + 6e^- = HS^- + 4H_2O$	-0.16	0 to -0.15
H_2 Formation		
$H^+ + e^- = \frac{1}{2}\ H_2$	-0.41	-0.15 to -0.22
CH_4 Formation (example of fermentation)		
$(CH_2O)_n = n/2\ CO_2 + n/2\ CH_4$	--	-0.15 to -0.22

[a]Bohn et al. (1979).

Both of these are eventually converted to carbohydrates. A half reaction illustrating the release of energy from carbohydrate oxidation is:

$CH_2 = C^{4+} + H_2 + 4e^-$.

Several other minor reducing agents in soil parent material are present. They are nitrogen in the form of ammonia ($-NH_2$) and ammonium (NH_4^+), sulfur in the form of sulfhydryl (-SH) groups, Fe^{2+}, Mg^{2+}, and SO_2.

The term "equilibrium potential" suggests that all oxidation and reduction reactions in soil systems are equal and reversible. According to Bohn et al. (1979) this is far from reality. An activation energy barrier must be overcome before electron transfer can occur. Therefore, soil systems are characterized by a hindrance of electron transfers resulting in irreversible reactions. Extra energy can and does overcome the activation energy barrier which in turn results in oxidation-reduction reactions responding slowly to change in electron potential.

Patrick (1960), Bohn (1971), Gambrell et al. (1975), and Schwertmann and Taylor (1977), to name only a few references, report that within soil systems pH and Eh are related. Bohn et al. (1979) reports that Eh is dependent on the partial pressures of O_2 and H_2 and on pH. Changes in pressures of H_2 and O_2 have a minimal effect on Eh. For every tenfold change in P_{O2}, Eh will change 15 mV while for every tenfold change in P_{H2}, Eh will change 30 mV.

Buol et al. (1973) reported the importance of oxidation-reduction processes in soil. One of these reactions involves the weathering of iron from primary minerals. Bohn et al. (1979) has determined that iron redox processes occur in soil and that they proceed spontaneously without direct microbial activity. For example, oxidation or iron according to the following equation,

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

causes minerals such as biotite mica, glauconite, hornblends, and pyroxenes to break apart (Buol et al., 1973). Iron released in this process unites with either hydroxyl and/or oxygen thus forming iron compounds. Reduction of dissolved Fe^{3+} in soils is shown as:

$$Fe(OH)_2^+ + e^- + 2H^+ = Fe^{2+} + 2H_2O$$

where Fe^{3+} concentrations are very low. Bohn et al. (1979) goes on to say that reduction of goethite (solid phase) is most important. This reaction is:

$$FeOOH + e^- + 3H^+ = Fe^{2+} + 2H_2.$$

The form of iron in a soil system at any given time is determined in part by the linear relationship between Eh and pH. Bohn et al. (1979) and Buol et al. (1973) both show Eh - pH diagrams for iron. There is a definite correlation between Eh, pH and the form of iron ion present. For example, Fe^{2+} is predominant in a reduced and acid environment while Fe^{3+} predominates in a well oxidized and acid condition. Forms of iron such as FeS_2, $FeCO_3$, and FeOOH are dependent on Eh, pH, CO_2 and sulfur concentrations, and electron potential. Bohn et al. (1979) points out that FeOOH becomes increasingly unstable with increasing reduced conditions while $Fe(OH)_2$, $FeCO_3$, Fe_3O_4, and FeS_2 become more stable in this environment. Thus, iron solubility increases with increasing reducing and acidity conditions.

Variability of Eh measurements is caused because soil is not homogeneous but heterogeneous. Letey and Stolzy (1964) reported that ped surfaces adjacent to large oxygenated pores are under oxidized conditions while smaller interior monoxygenated pores could be under reducing conditions. Oxidation to reducing or reducing to oxygenated environments can occur within a distance of 5 mm.

Since a platinum electrode could be in contact with degrees of both oxidation and reduction, an electrode potential measurement provides an average index to oxidation-reduction processes. Birkle et al. (1964) concluded that method of placement of electrodes into the soil can cause variability in electrode potential values. Care must be taken to insure minimal change in soil-oxygen status of soil surrounding the platinum electrode. Any time a platinum electrode is inserted into the soil, oxygen contamination is possible. Therefore, measurements should be taken as soon as possible after electrodes are placed in the soil. Figure 69 illustrates the heterogeneous nature of soil and its effect on Eh.

Poise of the soil or the soil's ability to resist change in electrode potential reduces the possibility of rapid change from an oxidized to reduced condition. Bartlett (1981) states that aerated soils are highly poised. Additions of reduced O_2 via water and oxidized carbon (CO_2) will have no effect on electrode potential or poise. Therefore, the number of electrons required to change electrode potential, poise, is not effected. The largest single electron acceptor in aerated soil is O_2, and O_2 is adequate to accept all electrons from oxidation of organic

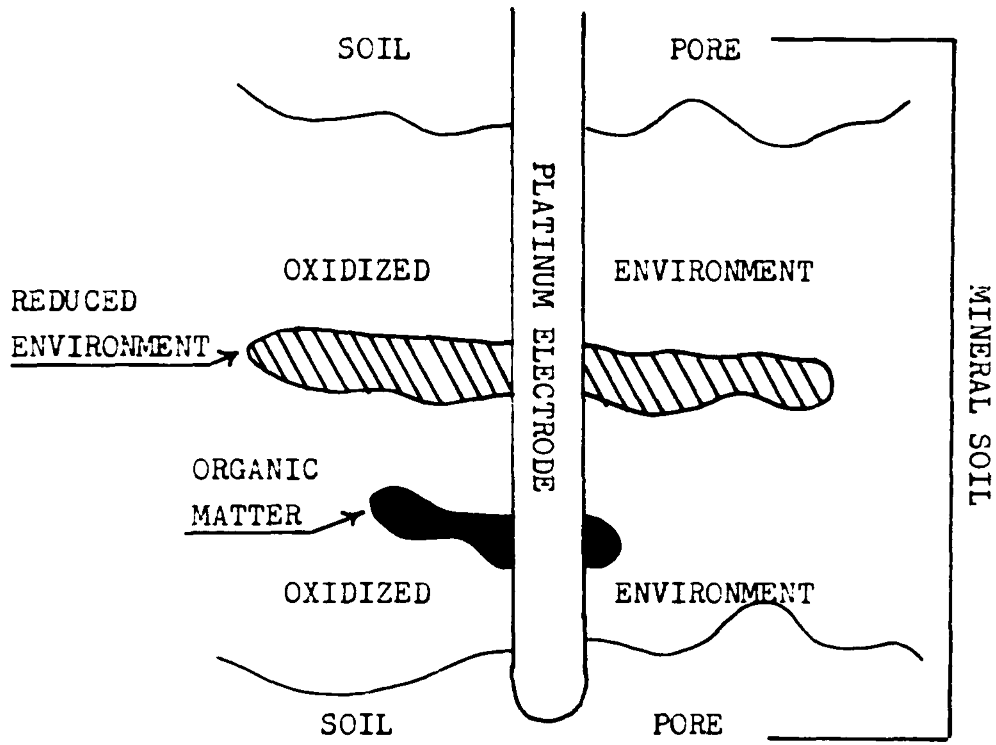


Figure 69. An illustration showing possible micro environments encountered by platinum electrode during E_{cal} measurements

matter.

To emphasize the extent, applicability, and possible problems of electrode potential measurements in soil systems, Bohn et al. (1979) lists several concerns. A synopsis of these concerns follows:

1. Electrode potential and redox potential values can and usually do differ widely. This is brought about because redox potential values expressed by the Nernst equation describe a condition of equilibrium. Electrode potential values do not reflect conditions of equilibrium but measure non-equilibrium soil systems.
2. In soil systems electron transfer between all redox couples seldom is equal.
3. Irreversibility of electron transfer between electrodes and ions is characteristic of soil systems. Since Fe(II-III) and H^+-H_2 couples are reversible redox couples, they strongly influence Eh.
4. Since redox potentials measure the potential for transfer of electrons, redox couple concentrations effect Eh values. The higher the concentration of redox couple the greater the possibility for electron transfer with the electrode.
5. Electrode potential is a measure of mixed potentials. Each redox couple contributes, but its specific effect on overall electrode potential value is unknown.

METHOD AND MATERIALS

Laboratory Procedures

Construction of platinum electrodes

Platinum electrodes were made by sealing a 20 mm length of number 18 platinum wire in one end of 4 mm soft glass tubing. One end of glass tubing was heated with a Bunsen burner until it melted and sealed around the platinum wire. Five mm of platinum wire extended beyond the end of the sealed glass tube. This glass tube was filled with mercury. About 5 mm of insulation was removed from one end of number 20 copper insulated wire. The bare copper wire was then inserted into the glass tube containing mercury until the copper almost touched the platinum wire. Epoxy glue was used to seal the top end of the glass tube. Figure 70 diagrammatically illustrates a finished electrode.

All platinum electrodes constructed were checked for accuracy. A capillary wick calomel electrode was used as a reference electrode. Then the platinum electrode was referenced to the calomel electrode in quinhydrone dissolved in pH 7 buffer and the potential read on a voltmeter. If it did not yield a mV value of 41 $\pm$ 5, the platinum electrode was discarded (Bohn, 1971).

Three platinum electrodes were glued together in a circular fashion with epoxy glue. Care was taken to insure that all spaces between electrodes were filled with epoxy resin. The three electrodes were then attached to the inside of a 1.6 cm x 40 mm PVC tube with epoxy resin. Again using epoxy resin the tube containing the three electrodes was

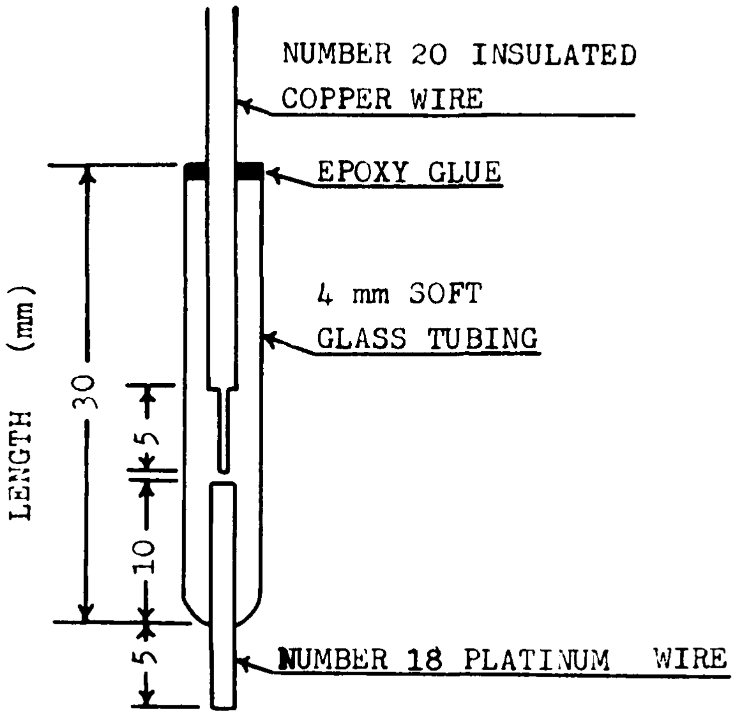


Figure 70. Cross section of a finished platinum electrode

to a 168 x 2.5 cm PVC tube. A 90^{0} 2.5 cm elbow was attached between the 168 x 2.5 cm tube and electrodes. Figure /1 shows a cross section of the final field-ready platinum electrode apparatus.

Laboratory experiment

A laboratory experiment was conducted to check the validity of using platinum electrodes to measure electrode potentials. To do this, the top was cut off a 190 l non-functional hot water tank. A 7.6 x 152 cm PVC tube which had 3 cm holes drilled along a vertical line at a distance of 30 cm apart was placed in the center of the hot water tank. The purpose of the 3 cm holes was to provide access to adjacent soil for electrode potential measurements. A rubber stopper was attached to the bottom end of the PVC tube before placing it in the hot water tank. Nicollet A horizon was placed between the outer wall of the hot water tank and PVC tube. Figure 72 shows a cross section of this apparatus during electrode potential measurement at the 121 cm depth. For the duration of this experiment, soil temperature was kept at $25^{0}C \pm 1^{0}$ and soil pH was 7.0. Water table fluctuations ranged from a depth of 45 to 125 cm.

Field Procedures

In order to measure in situ electrode potentials, 7.6 x 206 cm PVC tubes were inserted into the soil; 6.1 cm extended above the soil surface. Before placing these tubes in the soil, 3 cm holes were drilled 30 cm apart along a vertical line on one side of the tubes. When the tube was properly placed in the soil, these 3 cm windows provided access to adjacent soil for electrode potential measurement.

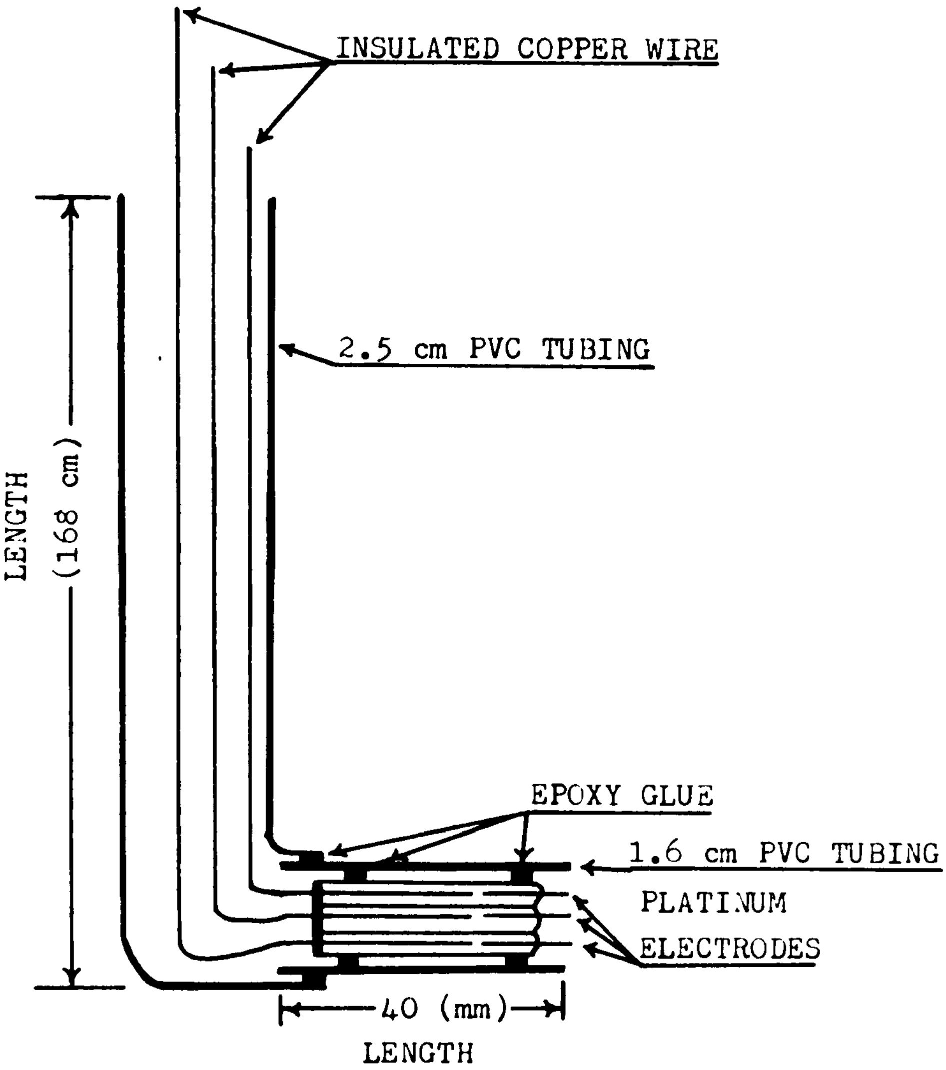


Figure 71. Cross section of the final field ready platinum electrode used to measure in situ E_{cal}

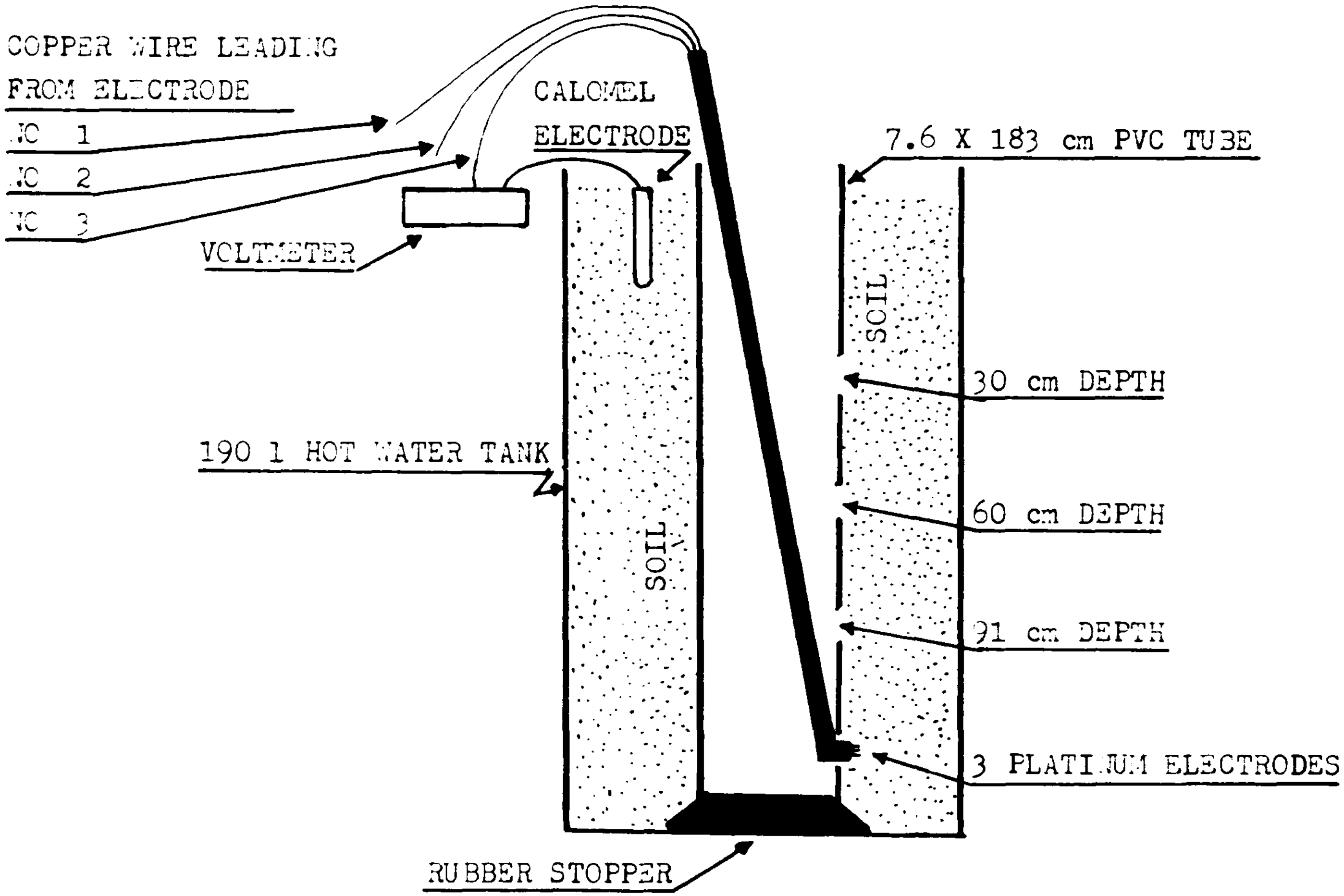


Figure 72. An illustration showing a cross section of laboratory apparatus used to measure electrode potentials

A capillary-wick saturated calomel electrode was used as a reference when measuring electrode potential. The calomel electrode was placed in the soil surface adjacent to the PVC tube.

A voltmeter, (2800 3½ digit portable multimeter which is manufactured by Dynasean Corporation, 6460 W. Cortland Avenue, Chicago, Illinois) was used to measure current. Figure 73 illustrates the arrangement of voltmeter, electrodes, calomel electrode, and access tubes during electrode potential measurement.

Electrode potential measurements were taken at 30, 60, 91, 121, and 152 cm depths in Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji in both undrained and artificially tile drained traverses. Each platinum electrode (Figure 73) was connected to the voltmeter and calomel electrode until a change of no more than $\pm$ 5 mV during a period of 1 minute was obtained. All three platinum electrodes were read in this manner before changing depths within a tube. Platinum electrodes were cleaned with a toothbrush that had been moistened with distilled water and sprinkled with Bon Ami detergent. Electrodes were then rinsed with distilled water before measuring electrode potentials at new depths. Electrode potential access tubes were kept stoppered when not being used to take measurements.

With the use of a hand probe, 30 cm diameter soil cores were taken beside each electrode potential access tube. The purpose of this soil core was to first determine temperature at the depth of electrode potential measurement. Secondly, approximately a 10 gram soil sample, collected at the corresponding depth of electrode potential measurement,

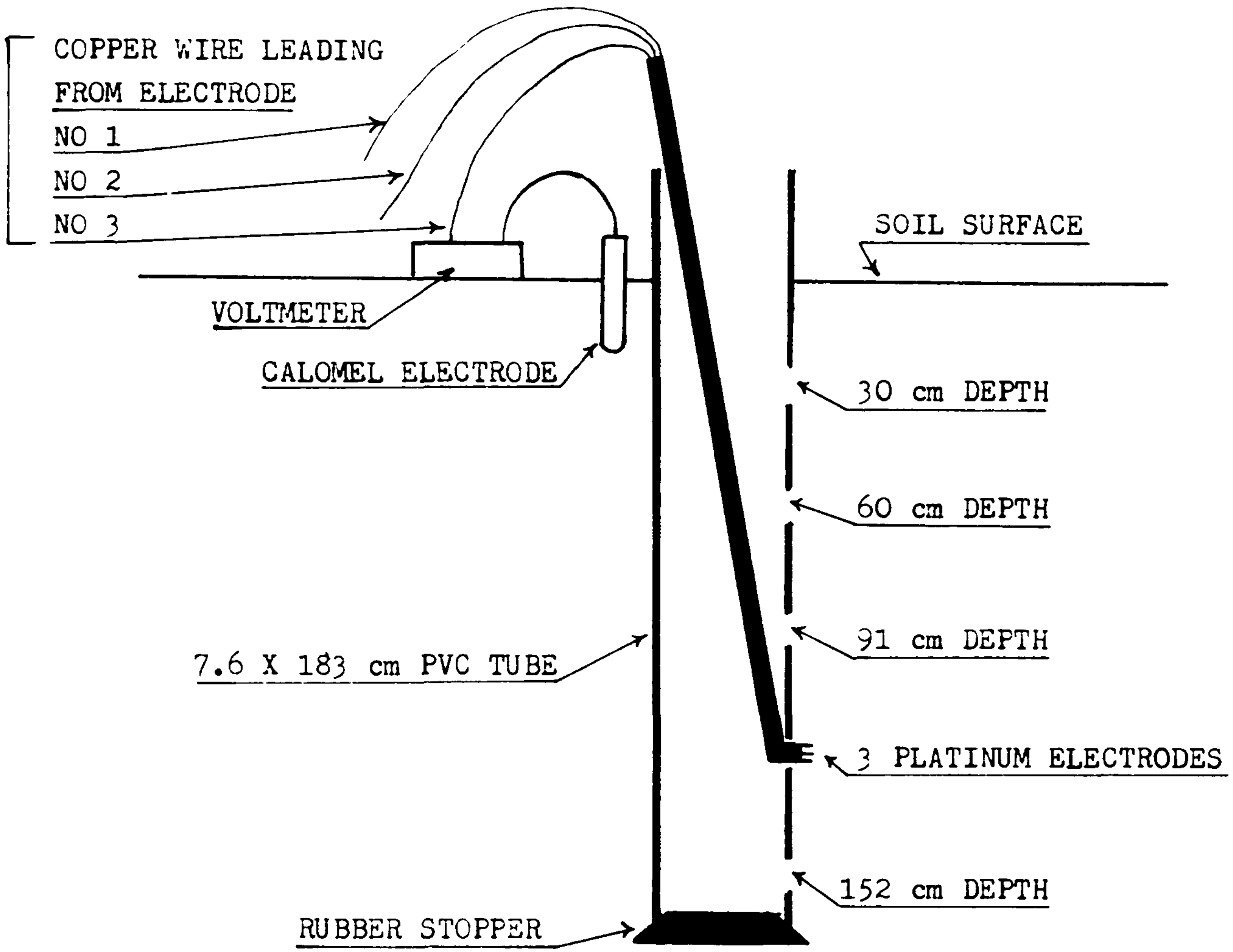


Figure 73. Cross section of apparatus used to measure in situ electrode potential measurements

was placed in a 100 ml plastic bottle containing 0.2% Agcl solution. Ferrous iron was determined on these samples. Thirdly, a corresponding sample was taken for pH determination. Appendix E lists all data pertaining to electrode potential measurements.

Since all electrode potential measurements were recorded in Appendix E as a distance above a base line, the corresponding distance below the soil surface must be calculated. For example, in TRV-1, SS-1, Month 6, Day 13, Year 79, the first DEHABL number is 5.5. This 5.5 m level above a base line is the same level as 0.3 m below the soil surface. Likewise, DEHABL values of 5.2, 4.9, 4.6, and 4.3 are 0.6, 0.9, 1.2, and 1.5 m below the soil surface, respectively. Water table values recorded in m's above a base line were also determined at the time of electrode potential measurement. Since water table depths are recorded as a distance above a base line the distance of water tables below the soil surface must be calculated. This can be done by adding 0.3 m to the largest DEHABL and subtracting the DWTABL or water table above a base line value. For example, the water table depth below the soil surface corresponding to the former example would be determined by adding 0.3 m to 5.5 m and subtracting 4.4. The water table depth below the soil surface is 1.4 m.

Electrode potential measurements were taken at Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji soil sites in both artificially tile drained and undrained traverses. Figure 4, Part I, shows location of each traverse in Story County. Figures 5 and 6, Part I, show location of each soil site within each traverse.

RESULTS AND DISCUSSION

Data collected during the laboratory experiment, Table 22, show that electrode potential can vary by as much as 800 mV within a short vertical distance. For example, on 1-8-79, Table 22, an electrode potential value (Eh) of +550 mV was recorded at the 30 cm depth while an Eh value of -300 mV was recorded at the 121 cm depth. These measurements also show large reductions in Eh just below the surface of the water table.

Initially, only one platinum electrode in conjunction with a reference electrode and voltmeter was used to measure electorde potential. It was soon realized that three individual readings at each depth by three individual platinum electrodes would provide a more accurate measure of the soil system. Data in Table 22, for dates of 2-5-79 through 3-9-79 are averages of these three readings.

Electrode potential (Eh) values ranged from +550 to -300 mV within a distance of 125 cm. These values were interpreted as conditions ranging from well oxygenated to severely reduced. It was concluded that platinum electrodes in conjunction with a reference electrode and potentiometer were capable of accurately measuring these conditions.

Electrode potential measurements for individual soils in both artificially tile drained and undrained traverses are presented in Appendix E. Figures 74 through 85 show plots of Eh and depth for each soil at each time of electrode potential measurement.

Table 22. Laboratory electrode potential data for Nicollet A horizon in hot water tank with controlled conditions

Date of measurement	Depth cm	Depth of water table cm	Time min.	Electrode no.	E cal. mV	Eh_7 mV
12-27-79	Water and sugar added to soil in tube.					
1- 4-79	30	45	5	1	+226	+460
	60	45	5	1	-534	-300
	91	45	5	1	-534	-300
1- 5-79	30	45	5	1	+206	+440
	60	45	5	1	-524	-290
	91	45	5	1	-520	-285
1- 5-79	Water table lowered.					
1- 8-79	30	110	5	1	+316	+550
	60	110	5	1	+295	+530
	91	110	5	1	+275	+510
	121	110	5	1	-534	-300
1-10-79	30	110	5	1	+402	+640
	60	110	5	1	+356	+590
	91	110	5	1	+282	+515
	121	110	5	1	-180	+055
1-10-79	Fresh water added.					
1-12-79	30	100	5	1	+416	+650
	60	100	5	1	+265	+500
	91	100	5	1	+309	+540
	121	100	5	1	+047	+280
1-15-79	30	89	5	1	+400	+635
	60	89	5	1	+372	+605
	91	89	5	1	+337	+572
	121	89	5	1	+143	+380
	130	89	5	1	+096	+330
1-15-79	Water table lowered.					

Table 22. (Continued)

Date of measurement	Depth cm	Depth of water table cm	Time min.	Electrode no.	E cal. mV	Eh_7 mV
1-22-79	30	125	5	1	+373	+605
	60	125	5	1	+361	+595
	91	125	5	1	+332	+565
	121	125	5	1	+075	+310
	130	125	5	1	+037	+272
1-24-79	30	122	5	1	+456	+670
	60	122	5	1	+408	+620
	91	122	5	1	+396	+605
	121	122	5	1	+254	+465
	130	122	5	1	+046	+255
2- 4-79	Made new platinum electrodes.					
2- 5-79	30	115	5	1	+333	+565
	30	115	5	2	+359	
	30	115	5	3	+378	
	60	115	5	1	+378	+590
	60	115	5	2	+374	
	60	115	5	3	+381	
	91	115	5	1	+256	+500
	91	115	5	2	+314	
	91	115	5	3	+287	
	121	115	5	1	000	+205
	121	115	5	2	-009	
	121	115	5	3	-008	
	130	115	5	1	-065	+145
	130	115	5	2	-066	
	130	115	5	3	-073	

Table 22. (Continued)

Date of measurement	Depth cm	Depth of water table cm	Time min.	Electrode no.	E cal. mV	Eh_7 mV
2-14-79	30	115	5	1	+294	+540
	30	115	5	2	+365	
	30	115	5	3	+327	
	60	115	5	1	+331	+540
	60	115	5	2	+356	
	60	115	5	3	+341	
	91	115	5	1	+227	+482
	91	115	5	2	+309	
	91	115	5	3	+276	
	121	115	5	1	-074	+130
	121	115	5	2	-076	
	121	115	5	3	-096	
	130	115	5	1	-121	+090
	130	115	5	2	-120	
	130	115	5	3	-122	
3- 9-79	30	125	5	1	+290	+550
	30	125	5	2	+339	
	30	125	5	3	+330	
	60	125	5	1	+382	+595
	60	125	5	2	+388	
	60	125	5	3	+379	
	91	125	5	1	+310	+515
	91	125	5	2	+308	
	91	125	5	3	+292	
	121	125	5	1	+092	+324
	121	125	5	2	+077	
	121	125	5	3	+126	
	130	125	5	1	-151	+065
	130	125	5	2	-145	
	130	125	5	3	-146	

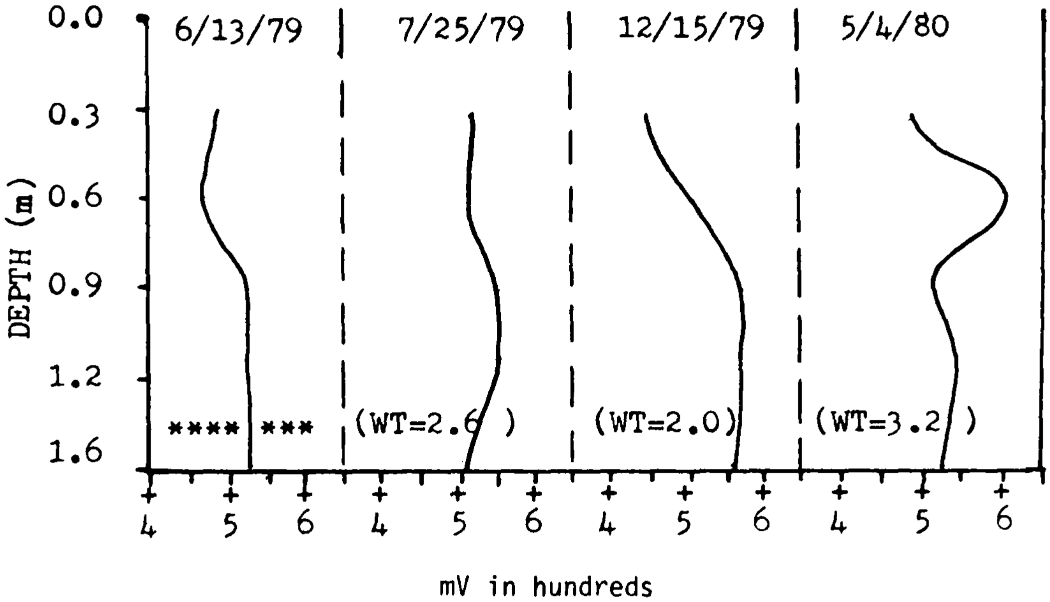


Figure 74. Eh values vs. depth for Clarion in tile drained traverse

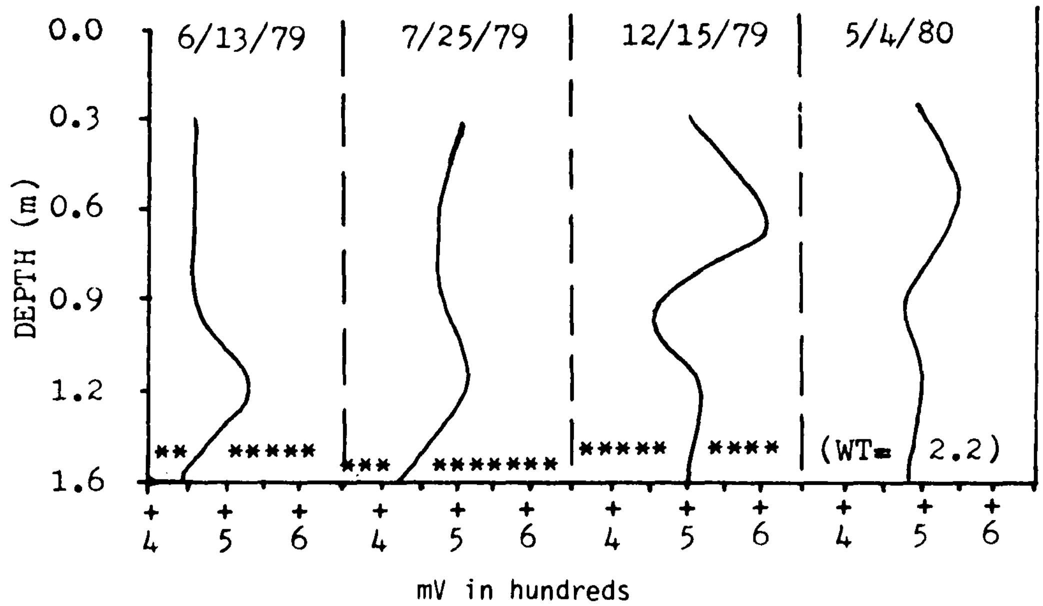


Figure 75. Eh values vs. depth for Nicollet in tile drained traverse

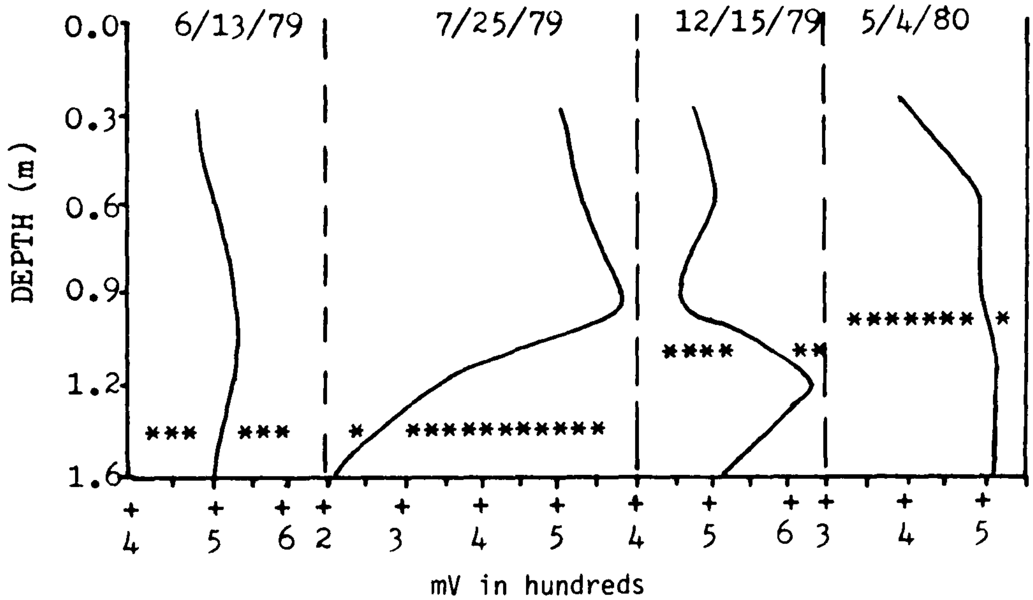


Figure 76. Eh values vs. depth for Webster in tile drained traverse

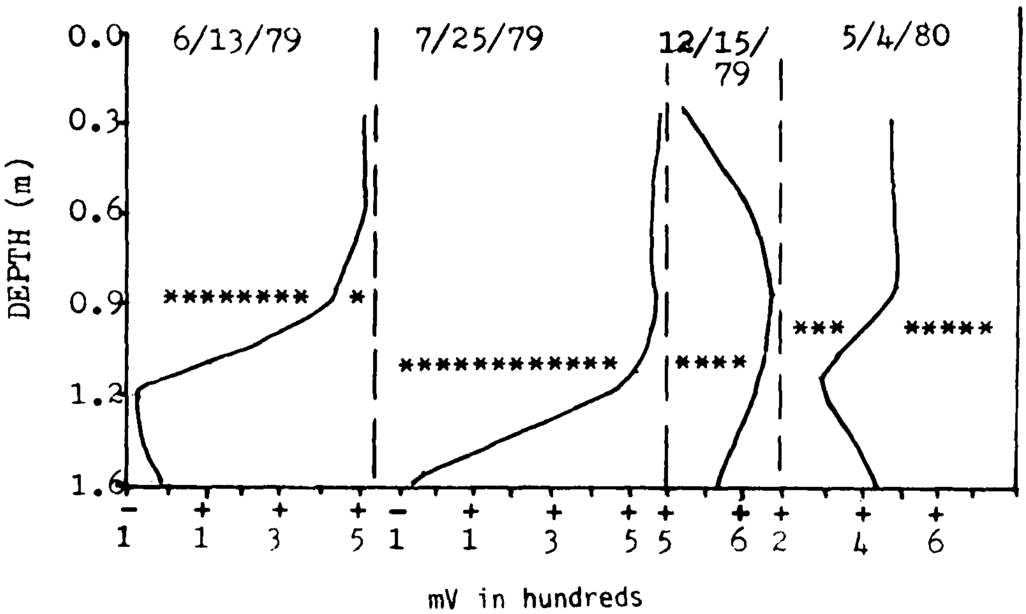


Figure 77. Eh values vs. depth for Canisteo in tile drained traverse

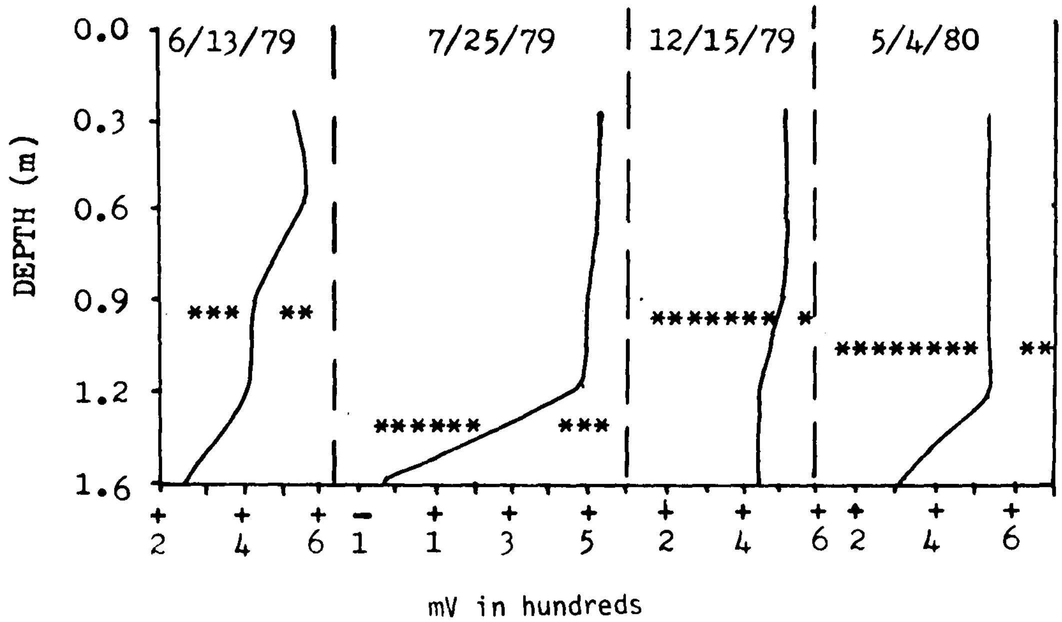


Figure 78. Eh values vs. depth for Harps in tile drained traverse

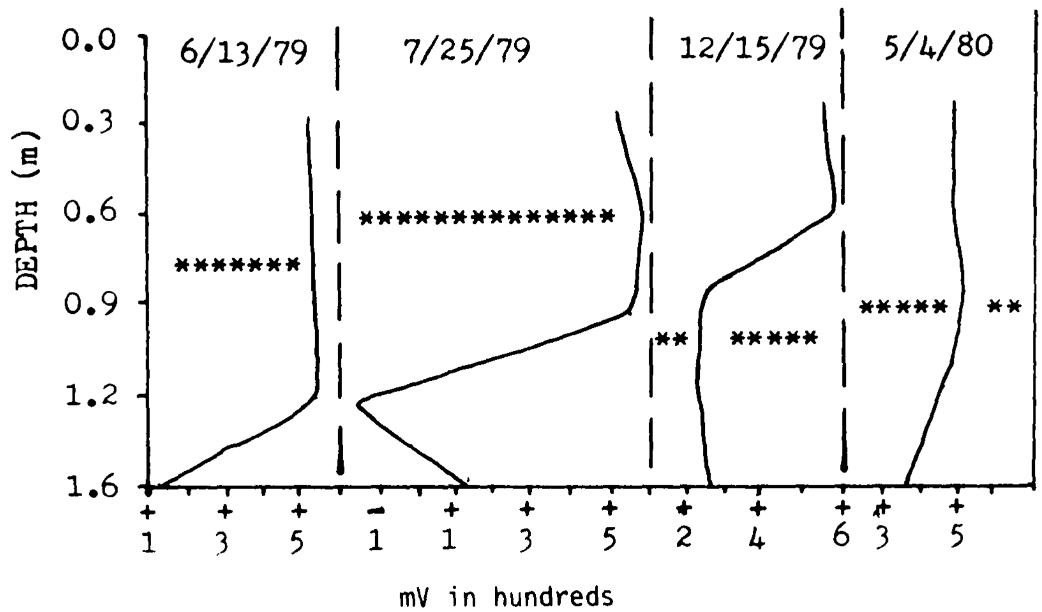


Figure 79. Eh values vs. depth for Okoboji in tile drained traverse

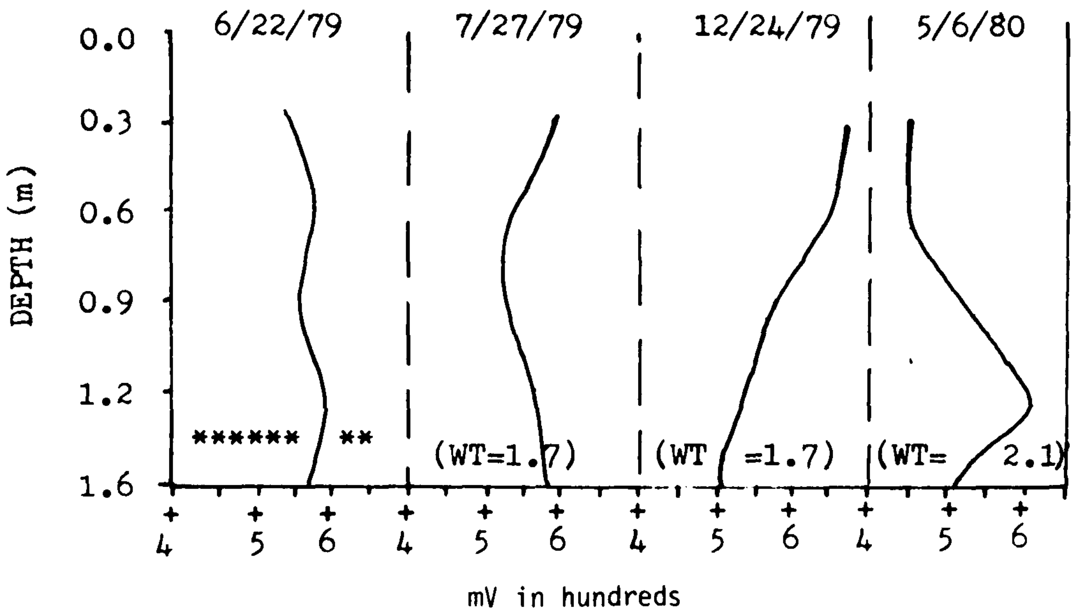


Figure 80. Eh values vs. depth for Clarion in undrained traverse

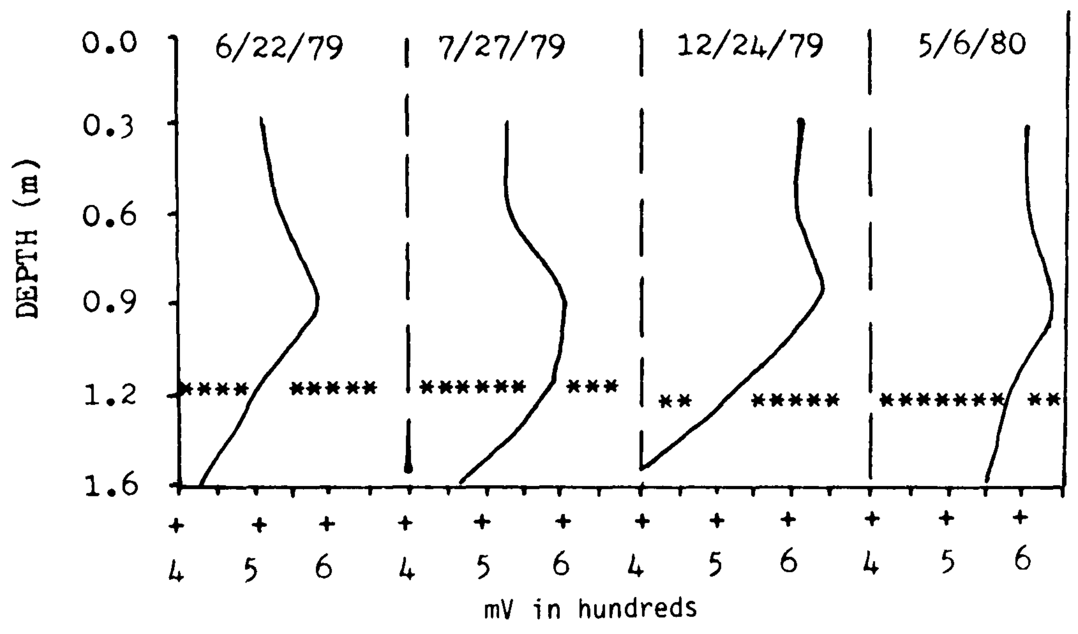


Figure 81. Eh values vs. depth for Nicollet in undrained traverse

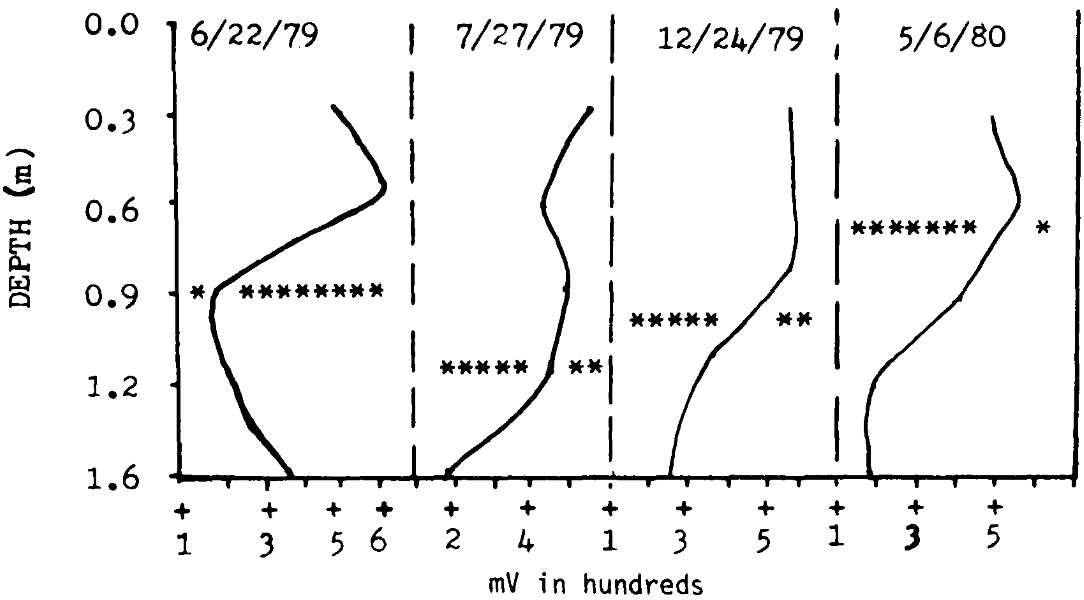


Figure 82. Eh values vs. depth for Webster in undrained traverse

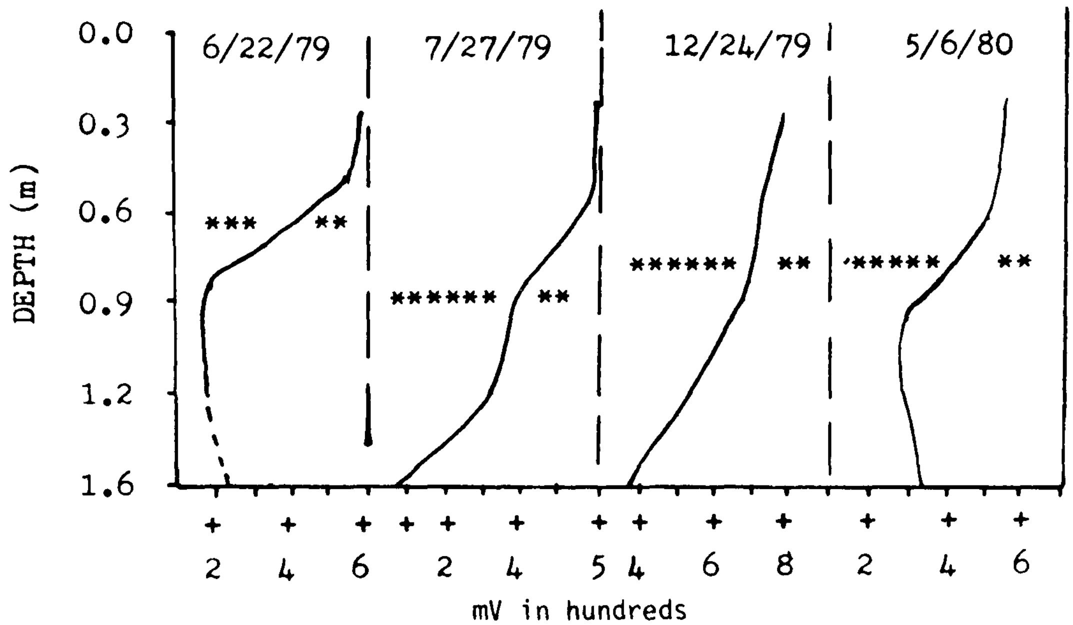


Figure 83. Eh values vs. depth for Canisteo in undrained traverse

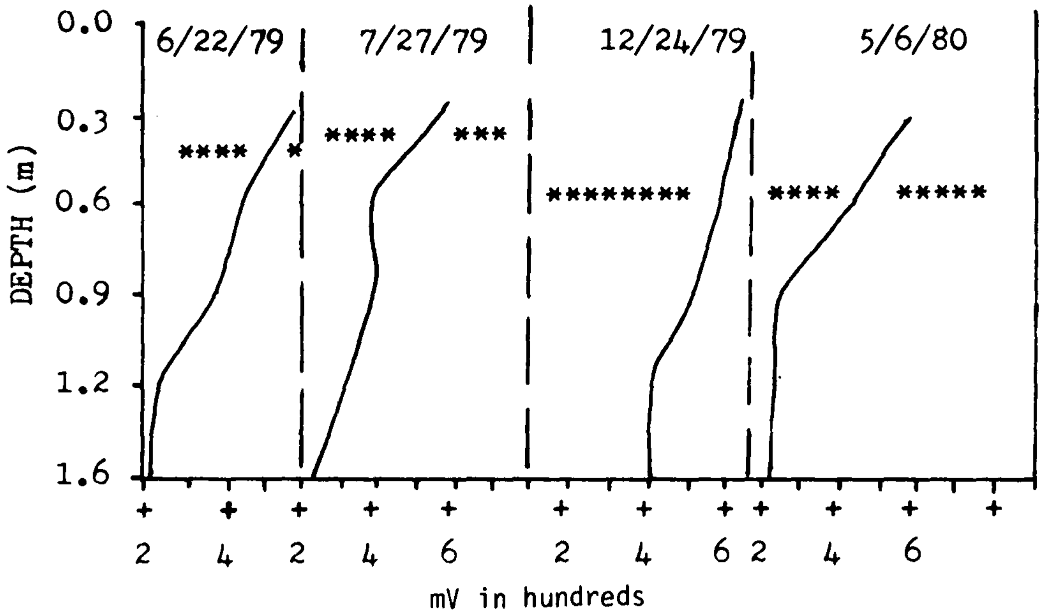


Figure 84. Eh values vs. depth for Harps in undrained traverse

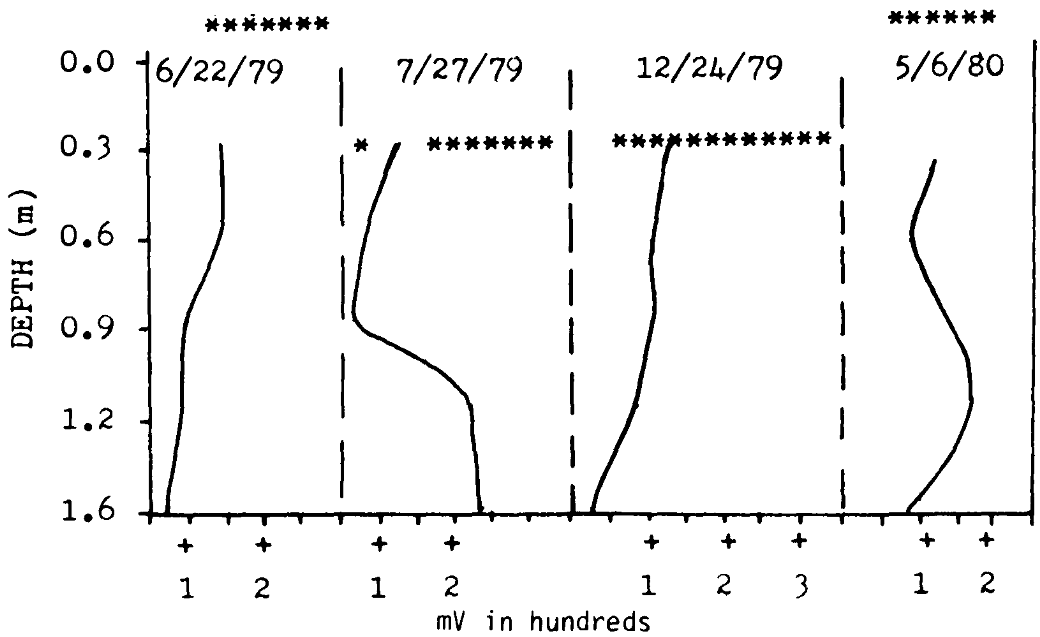


Figure 85. Eh values vs. depth for Okoboji in undrained traverse

Clarion - artificially drained and undrained Eh range

Electrode potential values ranged from +444 to +608 mV in both Clarion profiles with most Eh values falling between +500 and +600 mV. Eh values above +600 mV correlate with internal soil environments where oxygen is adequate and not being depleted. Eh values from +400 to +600 are interpreted as conditions where O_2 is being depleted. Since oxidation of organic matter can be more rapid than supply of the O_2, electron acceptor reactions overlap and proceed simultaneously. For example, some NO_3^- will accept electrons if the supply of O_2 is inadequate.

Eh values (Appendix E) for both Clarion soils for the duration of this discussion are interpreted as oxidative environments. Figures 74 and 80 show that Eh varies with depth. These vertical variations in Eh apparently relate to changes in percent water throughout the 0 to 1.6 m depth. These figures show that as the soil becomes dryer Eh values increase and as the soil becomes wetter Eh values decrease. Blanchar et al. (1981) concur with these findings.

Eh and water table   Highest water tables in both Clarion profiles occurred during a time between May 1 and July 1 (Figures 7 and 14, Part I). During this time the depth to water table ranged from 1.1 to 1.5 m below the soil surface. Water tables were well below the 1.6 m depth during the remaining portion of each year of the study. Eh values for the Clarion in the artificially drained traverse (Figure 74, 6-13-79) and the Clarion in the undrained traverse (Figure 80, 6-22-79) show some influence of a water table presence at 1.1 to 1.6 m depths, respectively.

The O_2 supply is basically greater than the O_2 demand, even when a perched water table is present. An organic carbon percent of 0.2 to 0.1 at the 1.1 to 1.5 m depth (Appendix D) would correlate with little microbial activity and low O_2 demand.

Figures 7 and 13, Part I, which show monthly water table depth and duration by time from 11-1-77 to 10-31-80 indicate that depth to minimum water table surface from the soil surface occurs about mid-June. This distance between the soil surface and water table surface is 1.3 m. Surface of water table is below the 1.6 m depth throughout the remainder of the year.

Eh and soil color   Profile descriptions for both Clarion soils (Appendix B) show matrix colors for the A, B, and C horizons that are indicative of well drained environments. Soil matrix colors of 10YR 5/4 are interpreted as reflecting oxidizing conditions. It is assumed that since the A and B horizons of these Clarion profiles contain no gray mottles and since these B horizons are yellowish brown, these horizons have formed under oxidized conditions. Mottles in these Clarion C horizons indicate reduced conditions. These gray and reddish brown mottles have formed under environments conducive to alternate periods of oxidation and reduction.

Ferric oxide or hydroxide ped coats are reduced to ferric oxides or hydroxides. These mobile compounds migrate to areas where oxygen is located (such as adjacent cracks or plant roots) where they are oxidized again to ferric oxides to precipitate on preexisting ferric oxide surfaces. This process would tend to strip the iron oxide coats from the mineral grains leaving an exterior mineral grain color of gray. Since the ped interiors would remain saturated for longer periods of time, there would be greater amounts of iron reduction at these interior ped positions (see Figure 69). Under conditions of reduction, when soil oxygen is unavailable to act as the final electron acceptor, Fe^{3+} will act as the final electron acceptor and be reduced to Fe^{2+}. This solubilized Fe^{2+} can migrate to areas when oxygen is present and be reoxidized to Fe^{3+}.

Even though these Clarion C horizons have well oxidized, 10YR 5/6 matrix color, brief periods of saturation, as explained in the previous discussion, could be responsible for formation of both gray and reddish brown mottles.

Electrode potential values of +444 to +662 mV that were measured in the A, B, and C horizons of both Clarion profiles are interpreted as oxidized conditions. Therefore, Eh values and soil matrix colors for the A, B, and C horizons correlate. Those mottles present in the C horizons do not correlate with measured Eh values. An explanation of how this could be possible is presented in the following paragraph.

There are two possible explanations. First, the method of measurement (Figure 69) is only an average estimate of all redox couples. Since there are only a few interior ped areas where reduction of iron ($FeOOH + e^- + 3H^+ = Fe^{2+} + 2H_2$) occurs, the chances of an electrode coming in contact with enough of these reduction areas to overbalance predominantly oxidized conditions is minimal. Thus, reduction of iron could occur but not be monitored because of being masked by oxidized reactions. A second possible explanation is that these mottles formed during a wetter environment during a prior time. Since oxygen can be depleted in a period of 24 to 48 hours following saturation and since duration of water table in the C horizons is for periods of up to about 60 days, the first explanation seems more logical.

It is assumed that all Cary till and parent material of all soils of this study was unoxidized and unleached (UU). This indicates that this Cary till was deposited under conditions of permanent water saturation. The uniformly gray color characteristic of unoxidized and unleached till has been interpreted as a situation where ferric oxides are often absent and the ferric oxide that is present is masked by ferrous oxides or hydroxides, thus giving the soil a greenish to black color. The gray color in the unoxidized till from which these Clarion soils have formed is due in part to ferrous oxides or hydroxides coating mineral grains, and, in part from the grayish color of Fe^{2+} in the outer structure of primary rock.

Since the UU till that is identified in lower horizons (Appendix B) contains strong ferric oxide or hydroxide mottles, it is modified unoxidized and unleached till. These brownish to reddish mottles in a grayish matrix are assumed to form from alternate oxidation and reduction. These Clarion profiles were not sampled deep enough to encounter unoxidized till matrix that is gray with yellowish brown mottles. Therefore, even at depths of 260 cm, alternate wetting and drying causing alternating oxidation and reduction reaction has occurred since deposition of till some 13,000+ years ago. Von Breemen and Brinkman (1976) also concluded that parent material under conditions of permanent water saturation is usually uniformly gray.

Eh and iron Percent free iron and iron oxide determinations are presented in Appendix D. Figure 86, Clarion in the tile drained traverse and Figure 91, Clarion in the undrained traverse, show free iron and ferric iron oxide percent remain constant from 60 to 270 cm. Free iron percent ranges from 1.4 to 0.8 in Clarion A and B horizons. Eh values of about +400 to -500 mV can be equated to free iron contents ranging from 0.8 to 1.4%. Free iron contents of about 0.6% were found throughout the 60 to 270 cm depth for both drained and undrained profiles. Distribution of free iron and iron oxide percent is shown in Figures 86 and 90 for Clarion soils in drained and undrained traverses, respectively.

Nicollet - artificially drained and undrained Eh range

Data presented in Appendix E show that Eh values ranged from +457 to +561 mV in the artificially drained Nicollet but ranged from -302 to +635 mV in the undrained Nicollet. A tile in the artificially drained traverse would keep water table levels lower in the profile than the undrained traverse. This tile would also tend to cause water to move through the profiles faster than in a non-tiled system. Water tables were within the undrained Nicollet at a depth of 1 to 1.5 m during a major portion of the year (Figure 15, Part I), while water tables were within the artificially drained Nicollet at a depth of 1.2 to 1.5 m for a much shorter duration (Figure 8, Part I). The net effect is that oxygen is continually added to the artificially drained Nicollet while there is a greater tendency for oxygen to be depleted and not replenished

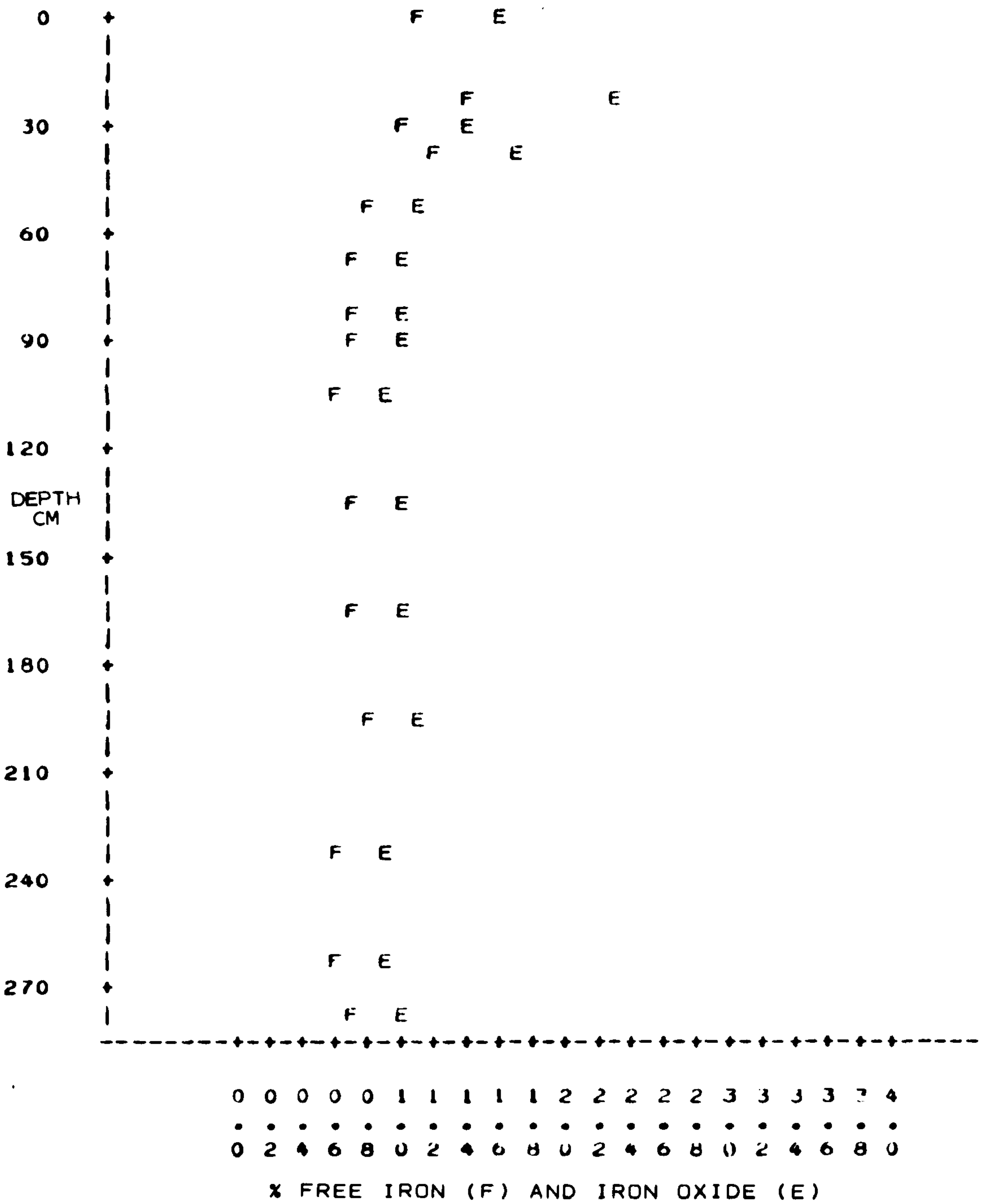


Figure 86. Plot of percent free iron and iron oxide with depth for Clarion in tile drained traverse

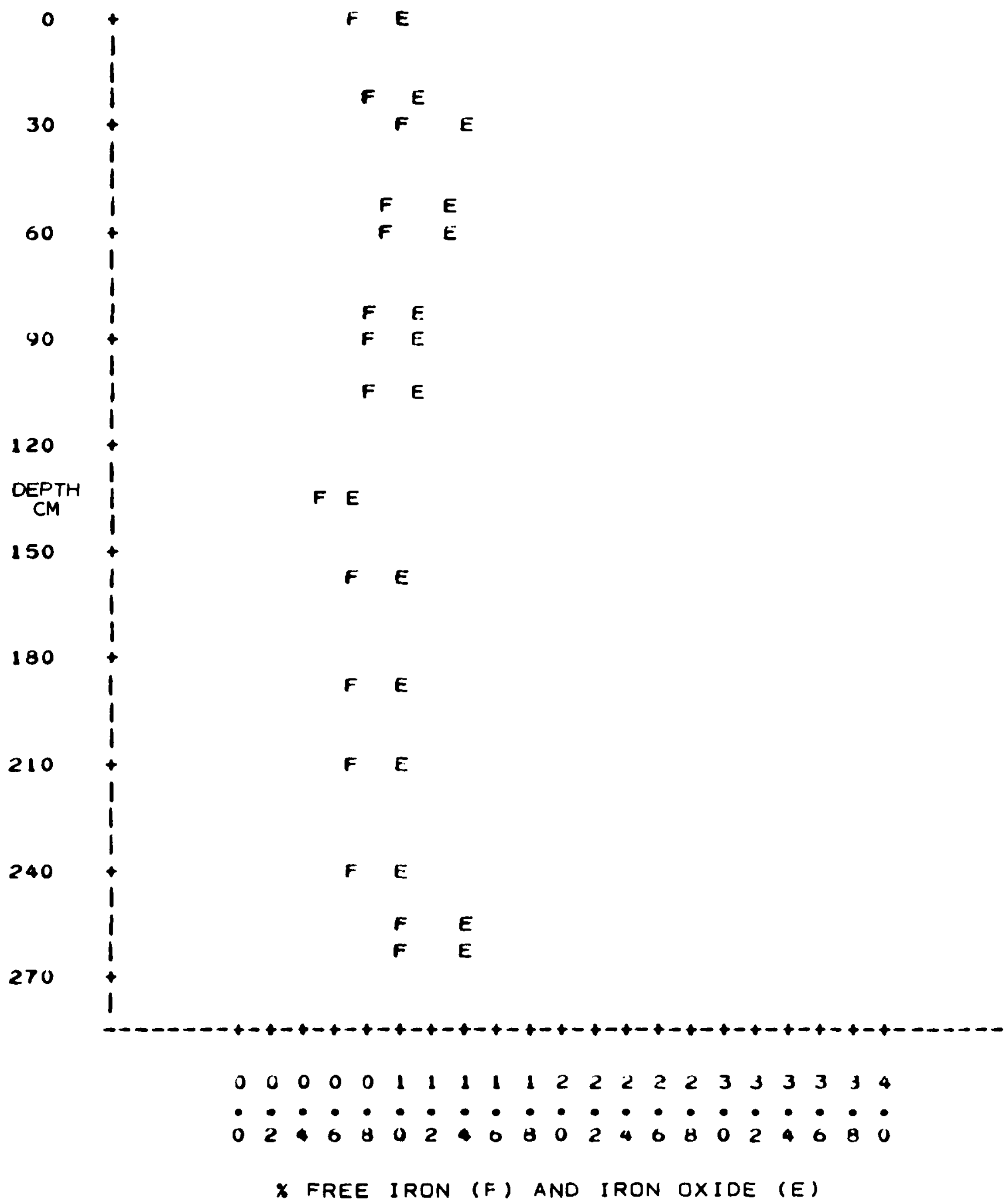


Figure 87. Plot of percent free iron and iron oxide with depth for Nicollet in tile drained traverse

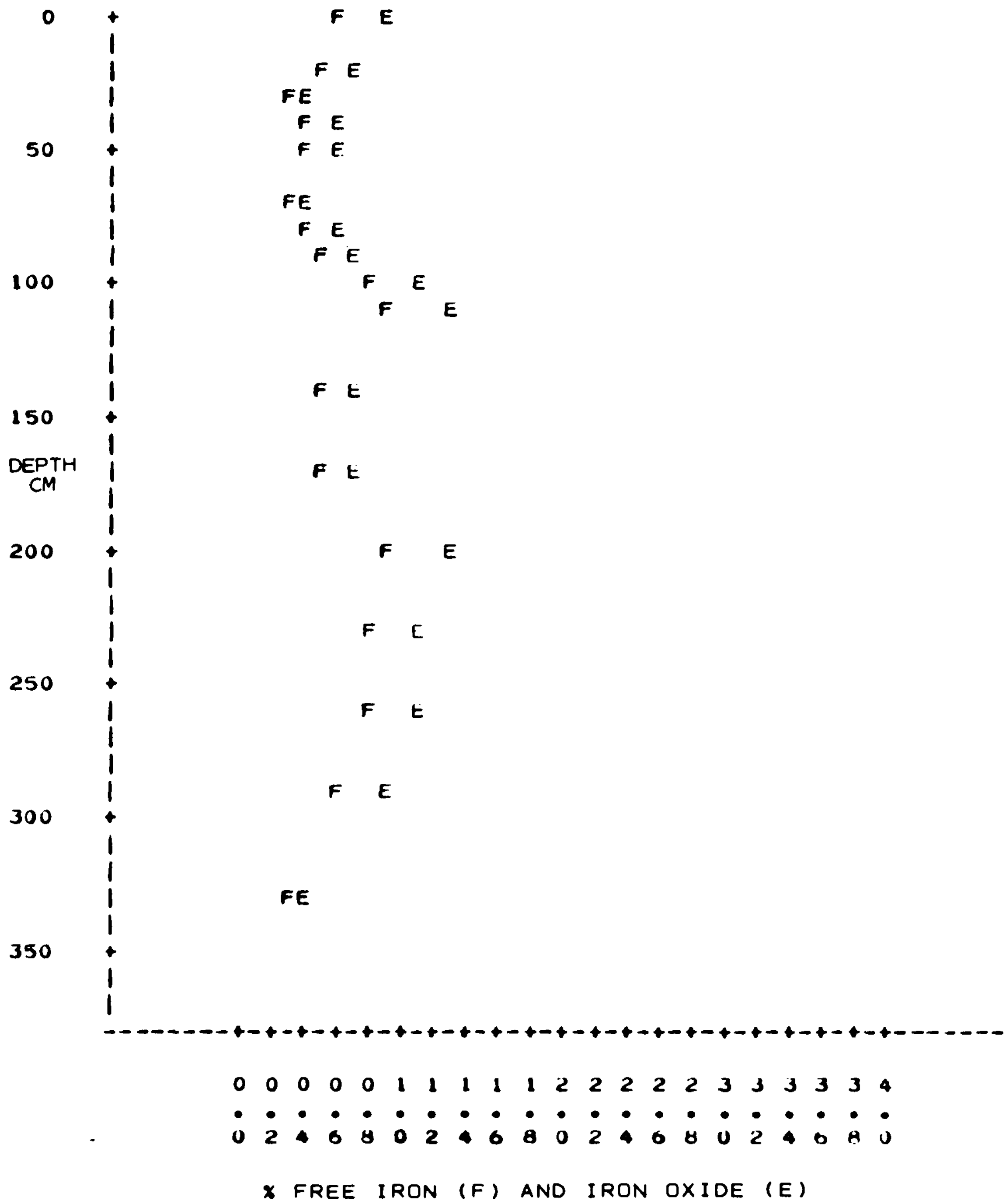


Figure 88. Plot of percent free iron and iron oxide with depth for Webster in tile drained traverse

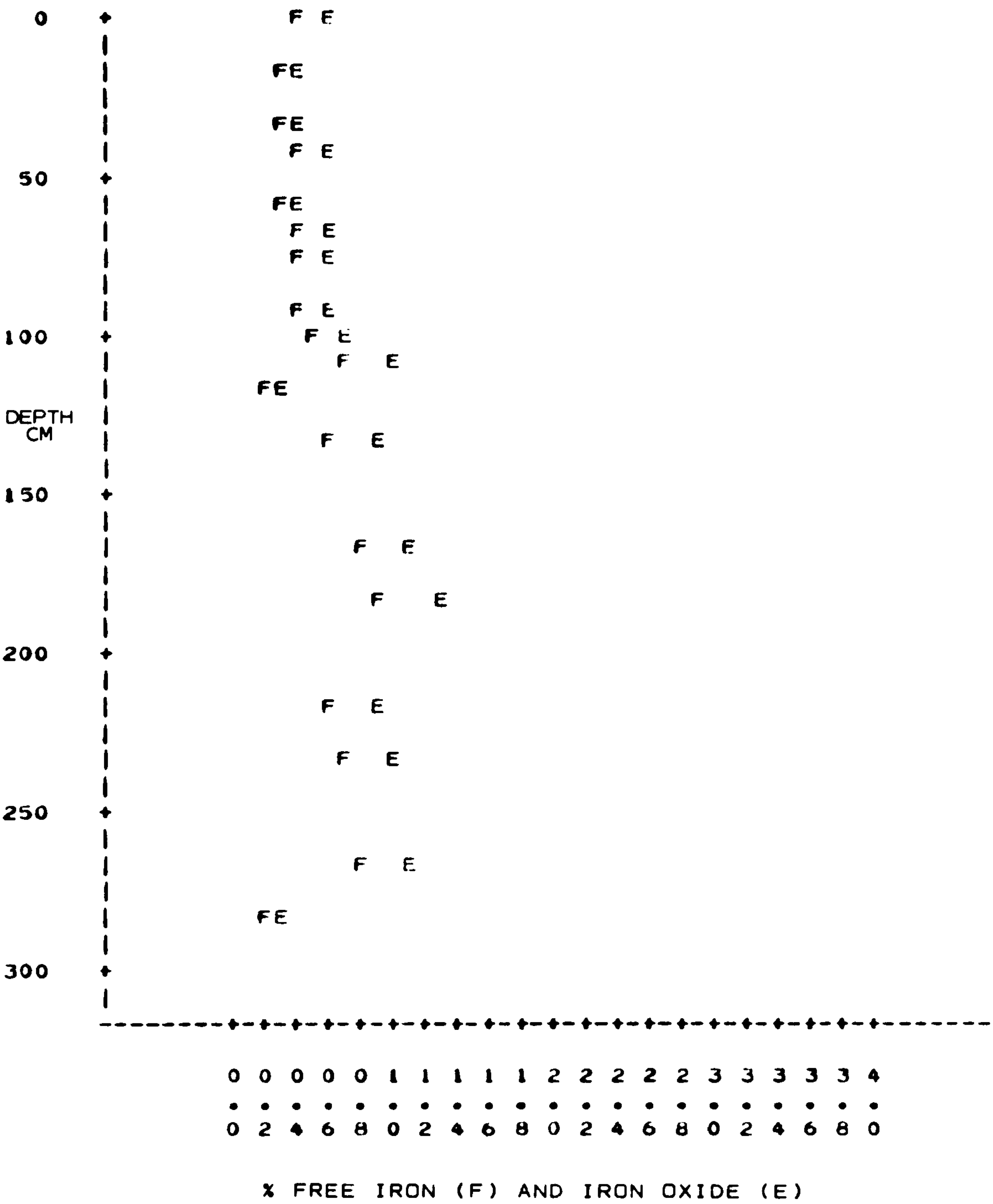


Figure 89. Plot of percent free iron and iron oxide with depth for Canisteo in tile drained traverse

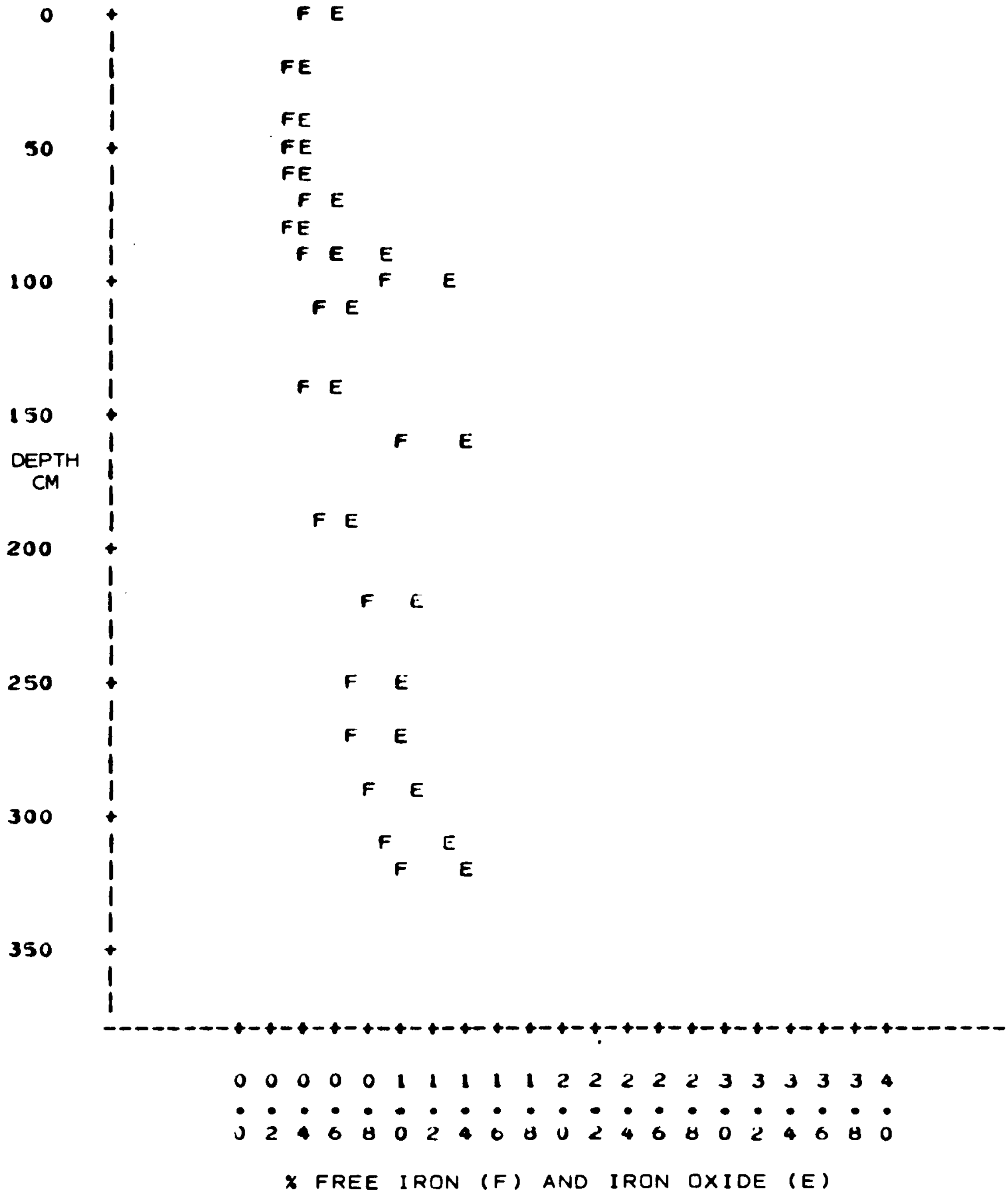


Figure 90. Plot of percent free iron and iron oxide with depth for Harps in tile drained traverse

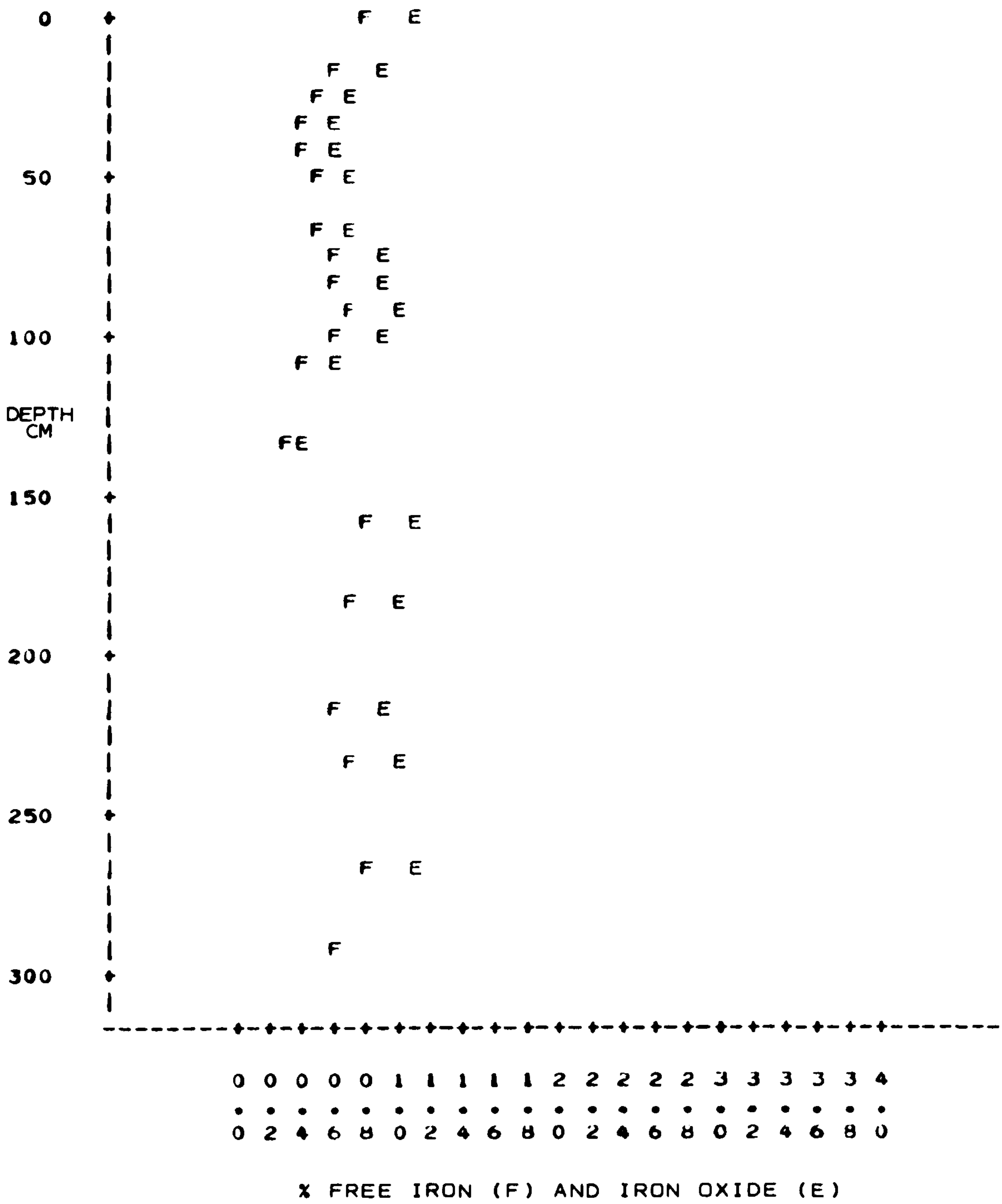


Figure 91. Plot of percent free iron and iron oxide with depth for Okoboji in tile drained traverse

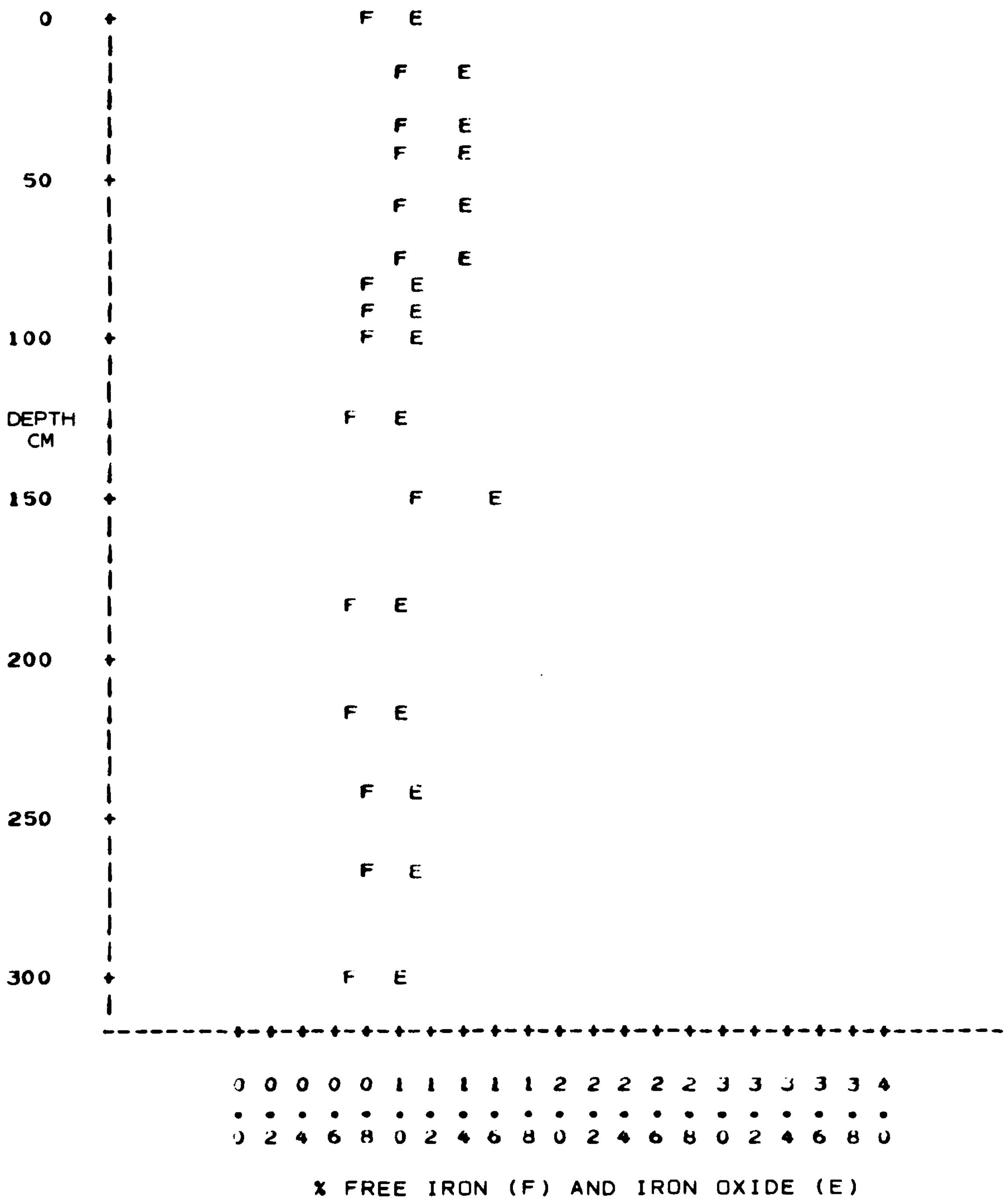


Figure 92. Plot of percent free iron and iron oxide with depth for Clarion in undrained traverse

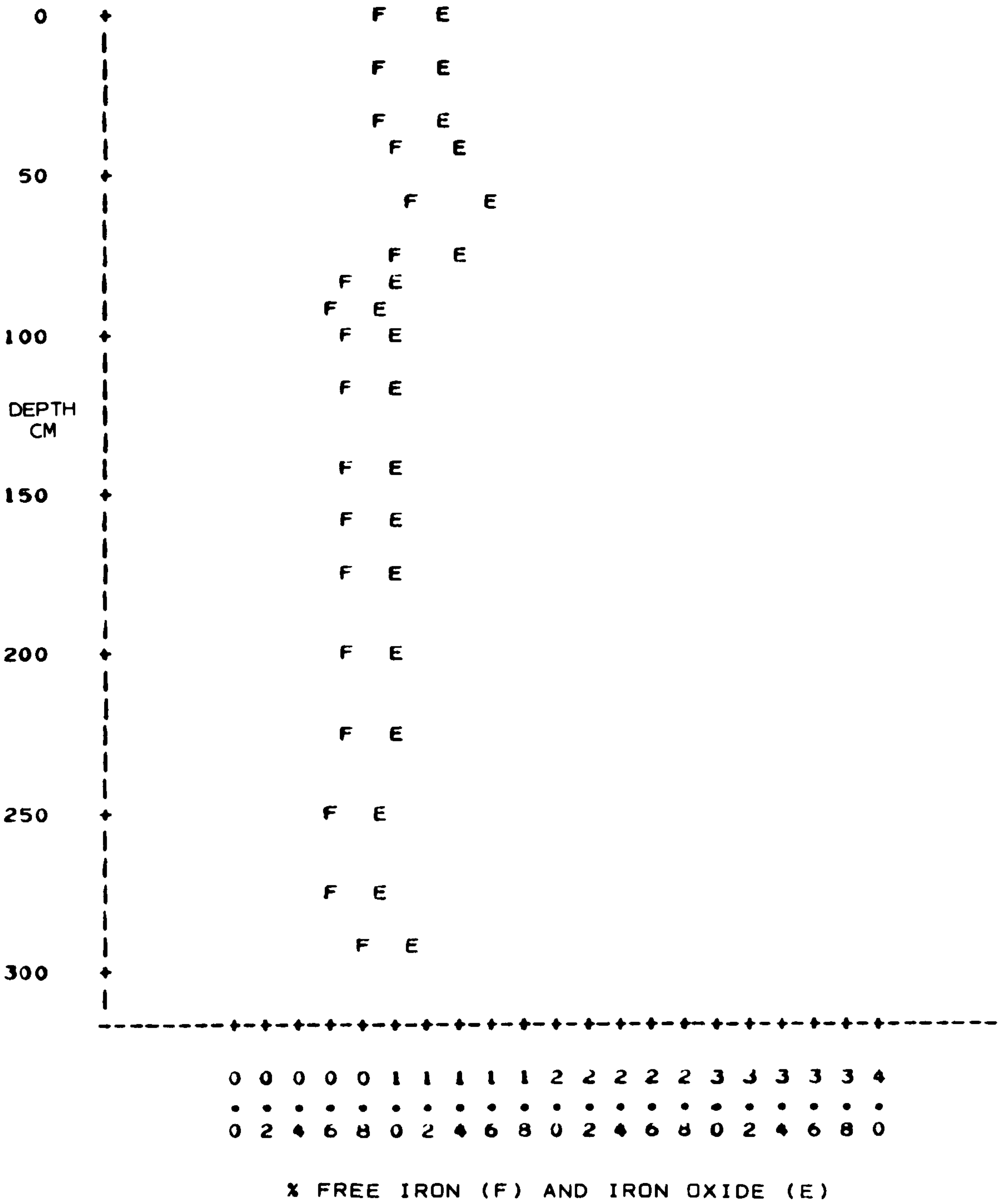


Figure 93. Plot of percent free iron and iron oxide with depth for Nicollet in undrained traverse

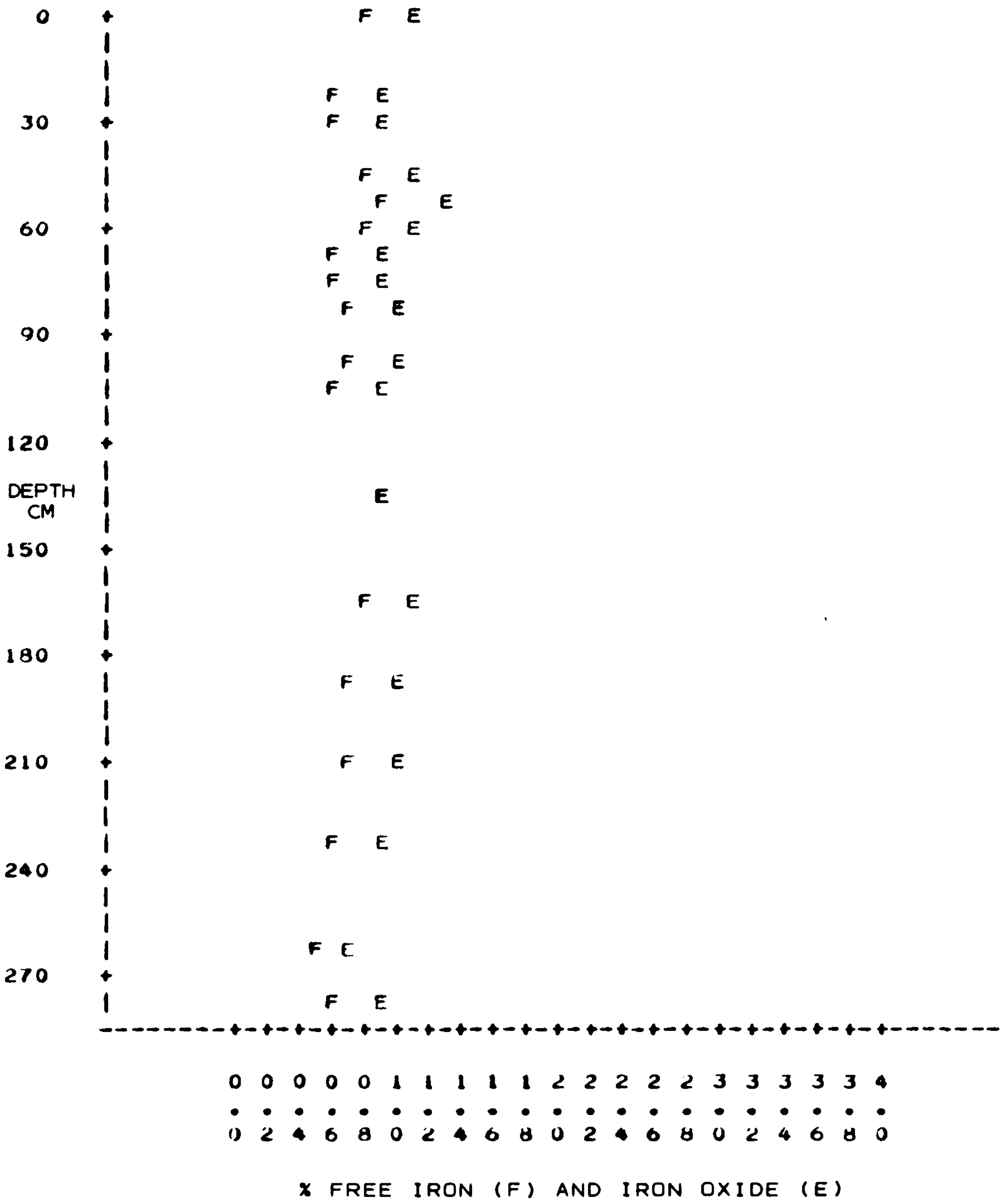


Figure 94. Plot of percent free iron and iron oxide with depth for Webster in undrained traverse

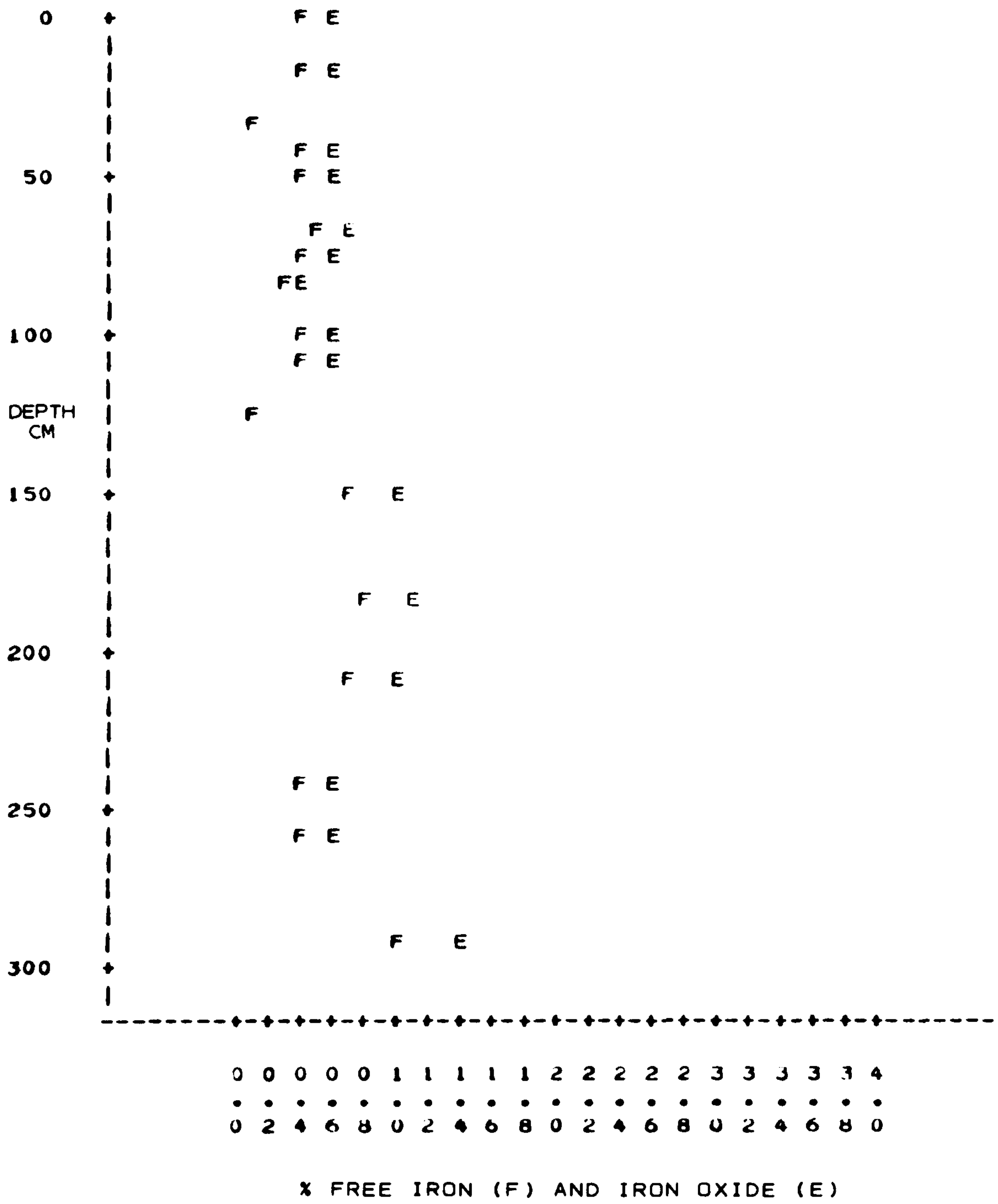


Figure 95. Plot of percent free iron and iron oxide with depth for Canisteo in undrained traverse

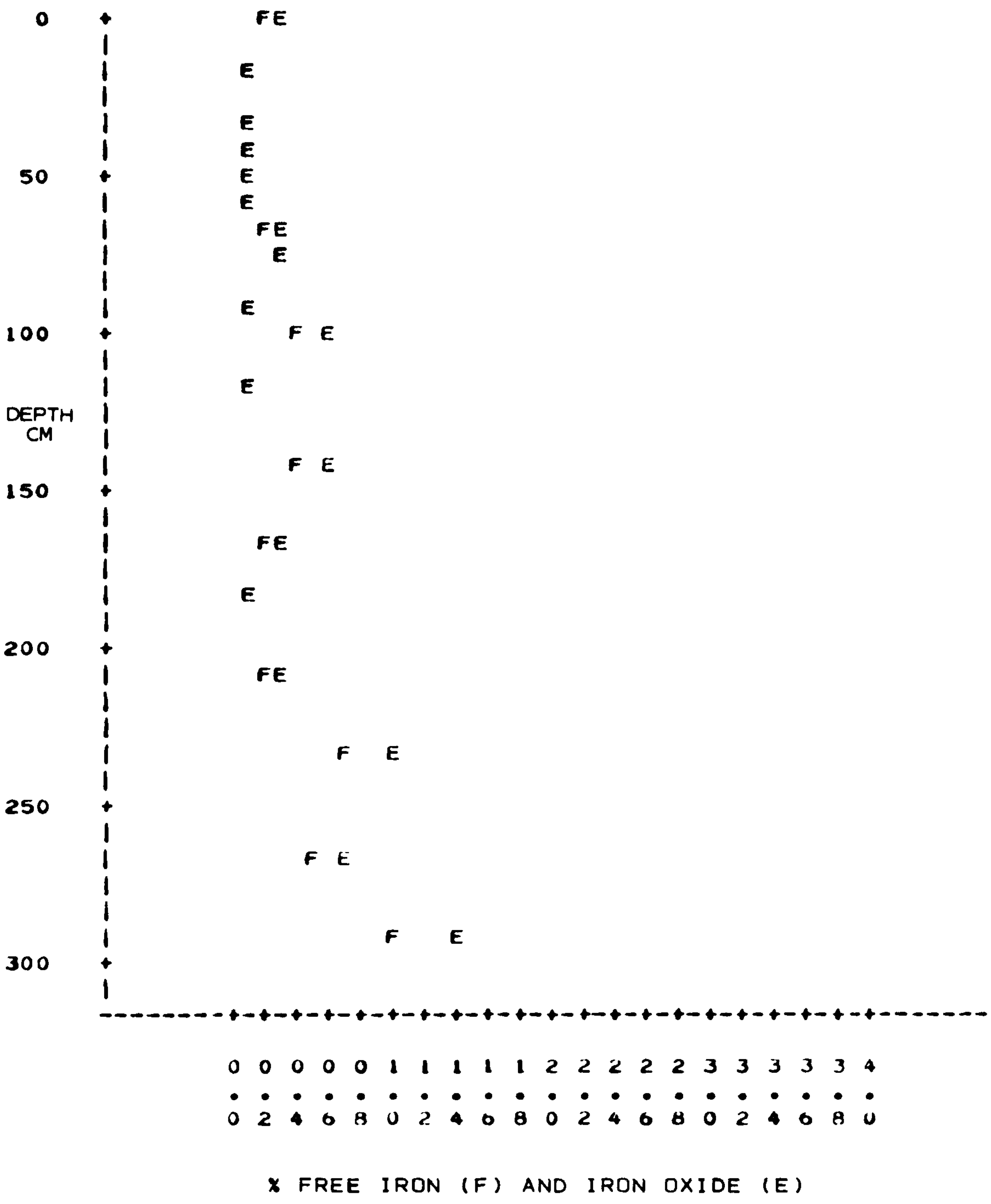


Figure 96. Plot of percent free iron and iron oxide with depth for Harps in undrained traverse

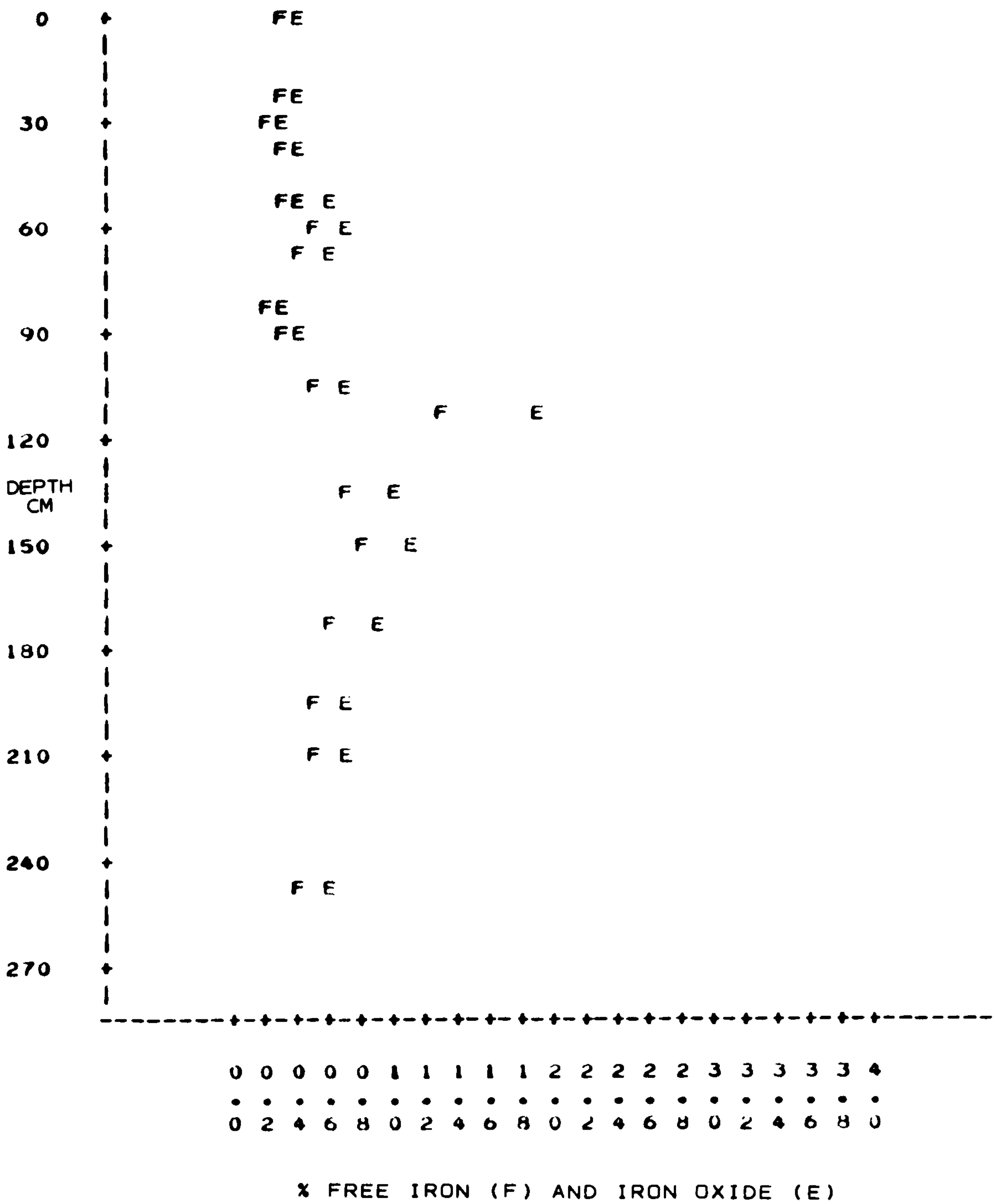


Figure 97. Plot of percent free iron and iron oxide with depth for Okoboji in undrained traverse

in the undrained Nicollet.

Appendix E lists Eh values for the artificially drained Nicollet that are interpreted as environments of oxidation. Eh values for the undrained Nicollet were much lower. For example, Eh measurement taken on 6-6-79 shows values at the 1.2 and 1.5 m depth of -302 and -275 mV, respectively. These values would certainly be interpreted as reducing environments. During most of the time of this study, Eh values indicate that both the artificially drained and undrained Nicollet were under conditions of oxidation.

Plots of mV by depth for these Nicollet profiles (Figures 75 and 81) show Eh variation with depth. As discussed for the Clarion soils, Eh variability relates to differences in percent water.

Eh and water table   Highest water tables occurred in the undrained Nicollet between April 15 and June 1 (Figure 15, Part I). Minimum depth to water table surfaces ranges from 0.7 to 1.1m. Generally depth to a water table surface during the duration of this study was about 1 m. Eh values (Appendix E and Figure 81) at the 1.2 and 1.5 m depth are consistently higher than would be expected for the duration of water tables at these depths.

Figure 75 shows a substantial decrease in Eh values in an area from about 0.2 m above the water table to the 1.5 m depth, but generally these Eh values were not low enough to be considered reducing environments.

Minimum depth to water tables (1.1 m) in the artificially drained Nicollet occurred between May 1 and June 15, then again between November 1 and November 15. Eh values of $>$ +450 mv that were recorded below the surface at a time approximating these high water tables do not relate to 10YR 3/1 colors. These colors have been interpreted as formed in a reducing environment.

Eh and soil color   Soil colors with a value of 2.5 to 7.5 and chroma of 1 or less have been interpreted as formed under environments of reduction (Soil Survey Staff, 1975b). Colors of 10YR 3/1 (mottles) in the artificially drained Nicollet that appear at a depth of 51 cm have been interpreted as reduced colors.

Soil matrix colors of 10YR 4/2 occurring about 0.5 m above minimum water table depths in the artificially drained Nicollet along with Eh values of +458 to +561 measured at these depths would suggest that soil colors in the B horizon of this soil are relict.

Eh values of -302 and -275 mV at the 1.2 and 1.5 m depths, respectively, in the undrained Nicollet on 6-6-79 describe reducing conditions where reduced matrix colors can form.

Strong brown mottles, 7.5YR 5/6, are noted in gray matrixes in both Nicollet B horizons. These ferric oxide or hydroxide mottles, according to Von Breemen and Brinkman (1976) have formed because of longer periods of oxidized conditions inside some structural minerals than the surrounding soil material. Even though there may be numerous oxidized mottles, the chances of a platinum electrode coming in contact with enough oxidized mottles within a 10YR 4/2 matrix to cause Eh values of +400 or higher are minimal.

Yellowish brown (10YR 5/4) matrix colors are present in both Nicollet C horizons. These horizons occur below zones of water saturation. Apparently the oxidized matrix color found in these C horizons has resulted from very slow reduction processes caused by low organic content.

Eh and iron Free iron percent (Appendix D and Figures 87 and 92) for artificially drained and undrained Nicollet, respectively, is less than free iron percent in the A and B horizons of either of the Clarion sola. Free iron percent in the C horizons of Clarion and Nicollet is nearly the same.

Generally, free iron content in both Nicollet sola is 0.2% less as compared to the sola of both Clarions, but Eh values are nearly the same in both Nicollet and Clarion sola.

Webster - artificially drained and undrained Eh range

Electrode potentials ranged from +197 to +646 mV in the artificially drained Webster and from +177 to +631 in the undrained Webster. Appendix E shows that reduced environments were closer to the soil surface for longer periods of time in the undrained Webster than in the artificially drained Webster.

Difficulty was experienced in measuring Eh for depths below water table surfaces in the undrained Webster. On several occasions, especially at the 0.9, 1.2, and 1.5 m depth on 6-22-79 and at the 1.5 m depth on 7-27-79, electrode potential values were indicative of reduced conditions. Initially, on these dates Eh values were about +120 mV but increased to +400 or +500 mV. Apparently, contamination of the platinum electrode surfaces with oxygen created false and inflated Eh values. When this happened, the time zero Eh values were used. Since Appendix E contains

Eh values for times when Eh only changed $\pm$ 5 mV in about 5 minutes, an Appendix E, Supplement is included. Appendix E, Supplement lists these time zero Eh values. Figure 82 includes these time zero Eh values. This problem of Eh values going from +120 mV to +400 mV was not found during any of the artificially drained Webster measurements. Birkle et al. 1964) also found that contamination of the platinum electrode during electrode potential measurement can be a problem.

Both Figures 76 and 82 show rapid changes in Eh with depth. Figure 82 shows that water tables have an effect on Eh values. Generally, Eh values become more indicative of reduction at depths just below the water table surface.

Eh, water table, and soil color   Water table levels ranged from 0.8 to 1.2 m below the soil surface in the artificially drained Webster (Figure 9, Part I). Reduced soil matrix (2.5Y 3/0) and gray mottles are in the artificially drained Webster as reported at a depth of 41 cm (Appendix B), but water table levels, at least during this study, were no closer than 0.4 m below these mottles. Electrode potential values between 0.3 and 0.8 m (Appendix E) ranged from +353 to +646 mV. Even though these mottles could have formed through the process of alternate wetting and drying at depths from 0.4 to 0.8 m, it appears that the soil matrix colors of 2.5Y 3/0, which are interpreted as formed in reduced conditions, are relict. Thus, it seems that Eh and soil colors do not relate at depths from 0.4 to 0.8 m.

Soil colors and Eh values do correlate below the 1.2 m depth. Eh values taken during the 7-25-79 measurements (Figure 86) are as low as

+197 mV. This rather low Eh at this depth is apparently due to organic matter in percolating water causing increased microbial activity. Usually at these depths, energy needed by microbes for reduction is a limiting factor. A +197 mV is considered to be a reducing environment.

From the above observations it appears that the tile has drastically modified chemical weathering environment, especially at the 0.3 to 1.2 m depths in the artificially drained Webster.

Data show closer agreement between Eh and soil colors in the undrained Webster. For example, on 6-22-79, Eh at the 0.9 m depth (Appendix E Supplement) was +123 mV while dark gray 5Y 4/1 matrix colors were first described at 51 cm (Appendix B). Figure 16, Part I, shows a water table surface only 0.5 m below the soil surface from February to March, 1977. Figure 82 shows large differences in Eh within short vertical distances. For example, Eh at the 0.6 m depth for 6-22-79, is +631 mV but only 0.3 m lower in the profile, Eh is +126 mV. The +126 mV is just into a water table. An increase in Eh from 0.9 m to 1.4 m is apparently related to slightly cooler soil temperatures, lower organic matter content and lower oxygen demand by microbes. Reduction may be occurring at the 1.4 to 1.6 m depth but at a much slower rate.

It appears then, based on the above paragraph, that Eh values relate with 2.5Y 3/0 soil colors and water table levels in the solum of the undrained Webster.

<u>Eh and iron</u> Free iron and ferric iron oxide percent (Appendix D, Figures 88 and 93) are somewhat lower in both Webster sola than in both Nicollet sola. This is probably related to larger amounts of ferric iron

oxide or iron hydroxide being reduced to the more mobile ferrous state and eventually being lost from the soil. Daniels et al. (1960) also found lower content of free iron in poorly drained environments than well drained environments.

There is a slight increase in percent free iron in the artificially drained Webster at the 100 m to 120 m depth. This increase in free iron is probably accounted for by water table phenomena, either upward movement and free iron deposition or lateral flow and deposition, or both.

Canisteo - artificially drained and undrained Eh range

The artificially drained Canisteo had lowest Eh values (-112 mV) during the 6-13-79 measurements while highest Eh values were recorded during the 12-15-79 measurements (Appendix E). Figure 77 shows large changes with depth. For example, there is a drop in Eh of 543 mV from the 0.9 to 1.2 m depth during the 6-13-79 measurements. Reducing environments were observed beginning at the 1.2 m depth during the 6-13-79 readings and at the 1.5 m depth during the 7-25-79 readings.

The undrained Canisteo had electrode potential measurements ranging in value from +188 to +777 mV. Again in this soil, as was noted in the undrained Webster soil, reduced environments are found higher in the profile for longer periods of time than in the artificially drained Canisteo or Webster soils. Lowest Eh values were recorded at a 0.9 m depth during the 6-22-79 measurements. Plots of Eh vs. depth are presented in Figure 83.

Eh, water table and soil color   Lowest Eh values for the artificially drained Canisteo that were recorded during the study correlate with highest water table levels. For example, an Eh value of -112 mV at the

1.2 m depth during the 6-13-79 measurement correlates with a water table level of about 1.2 m. Soil matrix colors of 5Y 4/1 are at a depth of 56 cm (Appendix B). It seems unlikely that since the tile drain maintains the water table surface at a level at or below a 1.2 m depth below the soil surface, 5Y 4/1 matrix colors could not form at depths between 56 and 120 cm under this present artificially drained environment. Electrode potential values tend to substantiate this idea.

Again, as in the undrained Webster, Eh, soil matrix color, and water table levels relate. Appendix E, Supplement, lists a +188 mV Eh value at the 0.9 m depth during the 6-22-79 measurements. Reduced soil matrix colors of 5Y 5/1 are at a depth of 51 cm (Appendix B). It seems likely that if Eh measurements were taken over a period of several years, reducing environments would be recorded at the 51 cm depth. Electrode potential values vs. depth are presented in Figure 83. The same general trend during each time of measurement is similar to the undrained Webster (Figure 82).

Eh and iron   Generally, depth distribution of free iron and iron oxide (Appendix D, Figures 88 and 93) for artificially drained and undrained Canisteo, respectively, are similar to the two Webster soils.

Harps - artificially drained and undrained

The lower range of electrode potential for the Harps artificially drained profile indicates reducing conditions only at the 1.5 m depth. Reducing environments were monitored at much higher positions in the profile for the undrained Harps (Appendix E). Figures 74 and 84 present depth distribution of Eh for each time of Eh measurement during this study. These figures illustrate that lower Eh values were found higher in the undrained Harps soil for longer periods of time than the artificially drained Harps.

Eh, water table, and soil color   Electrode potential values, soil color, and water table levels relate in the undrained Harps but they do not relate in the artificially drained Harps. For example, gray matrix colors are at a depth of 58 cm in the undrained Harps (Appendix B), while reduced conditions where these colors could have formed (Appendix E) were recorded at depths of 0.9 m.

Eh values conducive to reduced soil matrix formation are at depths of 1.4 m (Appendix E), while actual gray soil matrix colors are at a depth of 46 cm in the artificially drained Harps. It appears that the tile continually keeps water table levels well below the 46 cm depth.

Eh and iron   Percent free iron and percent ferric iron oxide are nearly the same as reported for the undrained Webster and Canisteo profiles (Appendix D). Depth distribution patterns are also similar (Figures 78 and 84). Generally, the undrained Webster, Canisteo and Harps data show that as percent free iron decreases, electrode potential also decreases. This relationship is not evident in the drained phase soils.

Okoboji - artificially drained and undrained

Appendix E shows Eh ranges from -126 mV to +590 mV for the undrained Okoboji while a +038 to a +221 mV are reported for the artificially drained Okoboji. The undrained Okoboji Eh values are low enough to be interpreted as reduced environments for all readings during all times of measurements. Reduced environments are reported at depths of at least 0.9 m for the artificially drained Okoboji.

Figure 79, artificially drained Okoboji, and Figure 85 illustrate depth distribution of Eh. The large decrease in Eh from 1.0 m to 1.3 m, Figure 79 (7-25-79) is apparently related to oxygen depletion through reduction of organic matter by microbial activity. Eh then increases from 1.3 to 1.4 m probably because of less organic matter resulting in less demand for oxygen.

<u>Eh, water table, and soil color</u> There is a good relationship between Eh, water table depths, and soil color in the undrained Okoboji. This relationship does not exist in the artificially drained Okoboji. As discussed previously, in the artificially drained Webster, Canisteo and Harps, a tile has kept these water table levels low, thus creating a more oxidized environment. Therefore, Eh values and water table levels suggest that soil colors in the solum of the tile drained Okoboji are relict.

Reduced environments are also conducive to accumulations of organic matter. Both Okoboji profiles have accumulations of organic matter but generally the undrained Okoboji has slightly more organic matter (Appendix D). These organic coatings tend to mask soil colors such as 5Y 3/0 that have been interpreted as formed in a reduced environment.

Electrode potential values ranging from +118 mV to +177 mV at the 0.3 m depth in the undrained Okoboji (Appendix E) correlate with water table depths (Figure 19, Part I). Since water tables were at or slightly above the soil surface during electrode potential measurements, these Eh values reflect reduced environments.

Eh and iron The undrained Okoboji has a slightly lower percent free iron than the artificially drained Okoboji (Appendix D). Figures 90 and 95 illustrate depth distribution of both percent free iron and ferric oxide for artificially drained and undrained Okoboji, respectively. The same relationship between percent free iron and Eh that was found in undrained Webster, Canisteo, and Harps is also found in this undrained Okoboji; Eh and percent free iron relate. For drained Okoboji, Eh and percent free iron do not relate.

SUMMARY AND CONCLUSIONS

In a laboratory experiment, platinum electrodes in conjunction with a reference Calomel electrode and voltmeter were capable of measuring electrode potentials ranging from well oxidized to severely reduced internal soil environments. It was shown that within a vertical distance of about 120 cm, electrode potentials (Eh) could vary from -300 to +550 mV and that within a vertical distance of only 30 cm electrode potentials could change from +550 to +055 mV. The magnitude of these electrode potential changes was related to depth and duration of water tables.

This method of estimating internal soil weathering environments was promising enough to merit its application to in situ electrode potential (Eh) measurements in soils. Six sites from a drained traverse and six sites from an undrained traverse containing well drained to very poorly drained soils were monitored over a period of one year to determine differences in electrode potential.

A platinum electrode has only the ability to measure the average of all redox couples adjacent to its surface. If the surrounding system is predominantly oxidized with only a few reduced areas, electrode potentials will be interpreted as oxidized conditions. If platinum electrodes encounter predominantly reduced redox couples with only a few oxidized redox couples, electrode potentials will be interpreted as reduced environments. This understanding is essential for interpreting high Eh values where gray mottles within an oxidized soil matrix are found.

Vertical electrode potential variations within a soil appear to be related to percent water and depth of water table. As soil became dryer, electrode potentials increased and as soil became wetter, electrode potentials decreased. Within a vertical distance of 150 cm, electrode potential differences of 600 mV were measured. Generally, sharp reductions in electrode potentials were measured at a depth of 0 to 30 cm below the surface of a water table. These electrode potential (Eh) values showed oxidized conditions just above the water table became highly reduced 15 to 30 cm below the surface of a water table.

Electrode potentials changed seasonally with soil moisture and water table fluctuations. Highest electrode potentials for unsaturated conditions were recorded in August when soil environments were the dryest, while lowest electrode potential values were measured in June when soils were the wettest. Electrode potential measurements also indicated that under saturated conditions such as a permanent water table, electrode potentials were generally constant. These were interpreted as reduced conditions.

Data showed that electrode potentials in an area between the water table surface and soil surface were usually indicative of oxidized environments. Since water table surfaces became closer to the soil surface from highest to lowest landscape positions, this oxidized zone became thinner with decreasing slope. Eh values interpreted as reduced environments were not found in Clarion sola of either drained or undrained traverses, but reduced environments were measured at the 0.3 m depth in the undrained Okoboji and 0.9 m depth in drained Okoboji.

Electrode potentials correlate well with soil color values of 2 or lower and chroma of 3 or higher for both drained and undrained Clarion soils. Both Eh values and soil color of these soils indicated that water tables play little, if any, role in modifying chemical weathering environments in these Clarion soils. Data show that free iron distribution of about 0.6% throughout tends to correlate with Eh values of +400 to +600 mV.

Electrode potentials relate to water table levels and soil color for undrained Nicollet, Webster, Canisteo, Harps, and Okoboji soils. Since these soils are still forming under natural moisture regimes, electrode potentials relate.

Electrode potentials do not relate with water table levels and soil color for artificially drained Nicollet, Webster, Canisteo, Harps, and Okoboji soils. Tile drainage has created a much more oxidized environment, especially from the 0.3 to 0.9 m depth in these soils. Artificial water table levels and electrode potential values suggest soil colors are relict. Free iron contents of 0.2 to 0.6% did not relate to Eh.

Use of platinum electrodes in conjunction with a reference Calomel electrode made it possible to estimate relative differences between chemical weathering environments for soils in both tile drained and undrained Clarion toposequences.

Electrode potentials should be measured over a period of several years in order to determine their accuracy in monitoring weathering environments.

GENERAL SUMMARY AND CONCLUSIONS

A study was undertaken to better understand the relationship between water table levels and soil forming processes in and between soils in an artificially tile drained and undrained Clarion toposequence. Each toposequence contained a Typic Hapludoll - Clarion, Aquic Hapludoll - Nicollet, Typic Haplaquoll - Webster, Calcic Hapludoll - Canisteo, Typic Calciaquoll - Harps, and Cumulic Haplaquoll - Okoboji. Both toposequences occupied closed depressions and both were located on the Des Moines lobe in Story County, Iowa.

These soils developed in an extreme midcontinental type climate that is characterized by wide fluctuations in temperature and rainfall. Parent material consisted of loam textured calcareous glacial till of mixed mineralogy. Till was deposited about 12,000 years ago, but soils show features that relate only to soil forming processes that occurred during the last 3,000 years. Soils have developed under a tall prairie grass vegetation on a landscape characterized by low knobs and associated shallow, somewhat circular depressions. Water collects in these small depressions.

Internal drainage for these soils in determined by topography. Each toposequence contains four drainage classes. They are as follows: Clarion = well drained; Nicollet = somewhat poorly drained; Webster, Canisteo and Harps = poorly drained; and Okoboji = very poorly drained.

Differences in physical and chemical properties between these soils were caused by differences in internal drainage. Depth and duration of water tables play an important role in determining internal drainage for several members of the Clarion toposequence. Changing depth and duration of water tables artificially through a tile drain would modify soil forming processes for several members of the Clarion toposequence.

The objectives of Part I of this study were to determine depth and duration of water tables for all soils in both tile drained and undrained traverses and develop mathematical water table prediction equations for each site and each traverse.

The objectives of Part II were to determine if there were differences in percent clay and total phosphorus distribution for all soils in tile drained and undrained traverses, and if there were differences, to relate these differences to depth and duration of water tables.

The objectives of Part III were to estimate internal weathering environments for all soils in tile drained and undrained traverses by in situ electrode potential measurements, and to relate these values to soil color and percent free iron to depth and duration of water tables.

Methodology

Part I

One representative artificially tile drained and one undrained Clarion toposequence were selected in Story County, Iowa. In order to determine watershed boundaries, a topographic map of each area was constructed. Detailed soil survey maps of these watersheds were also made.

Perforated plastic tubes were inserted into each most representative soil series site within each traverse. The soil series sites selected were within the range of respective National Cooperative Soil Survey USDA, SCS model profile description requirements. These plastic tubes were used as water table observation wells for the duration of the study.

Water table levels were measured and recorded at each observation well approximately weekly from November 1, 1977, through October 31, 1978, biweekly from November 1, 1978, through October 31, 1979, and monthly from November 1, 1979, through October 31, 1980. A battery-powered drop line meter was used to measure water table levels.

Regression equation variables for individual sites were as follows:

1. Antecedent precipitation (ANP) was defined as the amount of precipitation received at the site during a 30 day period prior to the date of water table (WT) measurement.
2. Cumulative precipitation (CP) was defined as the amount of precipitation received at the site between water table (WT) measurements. Both antecedent and cumulative precipitation for 11-1-77 through 10-31-80 were calculated from weather records of the Ames Pollution Control Center, Ames, Iowa.
3. Evapotranspiration (EV) was defined as the amount of evaporation either from the soil surface, through plant leaves, or both, that occurred from 1 to 30 days prior to the date of water table (WT) measurements.
4. Net percolating water (BPW) was defined as the amount of water percolating below a 152 cm depth.

Evapotranspiration (EV) and net percolating water (BPW) were calculated by a computer program estimating soil moisture under corn. These values were calculated from data collected on a Nicollet soil series site at the Agronomy and Agriculture Engineering Research Center located west of Ames along U.S. Highway 30.

5. Time (TDN) was defined as the day of the month and year of water table (WT) measurement.
6. Days between water table readings (DB) was defined as the number of days between water table (WT) measurements.
7. Water table (WT) was defined as the distance to the water table (WT) surface from the soil surface. These values were transformed to distances above a base line.

Regression equation variables for traverses in addition to those variables already mentioned for the individual sites were as follows:

1. Distance from edge of watershed to the individual site (SD),
2. Percent slope at each site (SL).

The initial regression models for water table level (WT) included the cubic function of time (TDN), quadratic functions of the other variables, all possible linear*linear interactions between variables, and the complex interactions of all other variables for individual soil series within each site of both traverses. Soils were combined in each traverse and these same functions were used to develop entire traverse models. Selection of final models was by stepwise, backward elimination of non-significant variates using the PROC GLM procedure.

Part II

One representative artificially tile drained and one representative undrained Clarion toposequence were selected in Story County, Iowa. Each traverse contained a Clarion, Nicollet, Webster, Canisteo, and Okoboji soil series (water table sites of Part I). Chemical properties of clay, phosphorus, organic carbon, and pH were selected to determine if there were differences between soils of drained and undrained traverses.

Soil cores were collected at each site within each traverse. Detailed soil profile descriptions were completed for each soil. Soil horizons were ground with a mortar and pestle and passed through a 2mm sieve. Particle size analyses and pH determinations were made on the 2mm soil samples. Soil horizon subsamples were collected from the 2mm horizon samples and ground with a mortar and pestle to pass a 100 mesh sieve. These finely ground subsamples were used for organic carbon, iron, and phosphorus determinations.

Part III

Platinum electrodes in conjunction with a reference Calomel electrode and voltmeter were successfully used to measure electrode potentials in a controlled laboratory experiment. This procedure was applied to a field situation.

PVC tubes were inserted into the soil at representative soil series sites of Clarion, Nicollet, Webster, Canisteo, Harps, and Okoboji in tile drained and undrained traverses, adjacent to water table access tubes, Part I. When the tube was properly placed in the soil, a 3 cm window provided access to adjacent soil for electrode potential measurements. In situ electrode potential measurements were taken at 30, 60, 91, 121, and 152 cm depths during a period of 1 year.

Results

Part I

Two major differences were noted in overall water table depth and duration between artificially drained and undrained traverses. First, a plot of mean monthly WT showed the water table surface was flat from Okoboji to Clarion in the undrained traverse. A plot of mean monthly WT showed a slight rise from Okoboji to Clarion in the drained traverse. The tile drain was apparently removing water faster from lower areas than the water could move laterally from farther up slope. Second, the water table surface was closer to the soil surface in the undrained traverse than in the artificially drained traverse. Generally, for any point on the undrained traverse, the water table surface was 70 cm closer to the soil surface than at a comparable position on the artificially drained traverse.

Artificially tile drained traverse - individual soil sites Final models for the artificially drained traverse showed that the mix of variates retained in the final regression models varied widely among soils. Significance levels of the retained variates also varied widely. The final model for Clarion had the most significant variates while those for Canisteo and Harps had the least.

Time (TDN) had a cubic effect on WT level in all except the Nicollet soil, but this effect was strong in the Clarion soil and weak in the Canisteo and Harps soils. The cubic effect of TDN was expressed primarily through its higher order interactions with one or more of the other variables.

Undrained traverse - individual soil sites   Although the effects of all variables on WT levels were not consistent among soils, all had varying significant effects in most soils.

Final models for the undrained traverse showed that variates differed among soils. Significance levels of the variates also differed. The linear and quadratic effects of the variables had greater significance in the models for the undrained soils than for the drained soils.

Time (TDN) had a strong cubic effect on WT level modified by interactions in the Nicollet and Webster soils, a weak cubic effect in the Clarion, Harps, and Okoboji soils, and only a quadratic effect with little interaction in the Canisteo soil.

All variables had varying effects on WT levels in most undrained soils.

Multiple regression analyses for all soils within each traverse The final prediction model R^2 for the artificially drained traverse was 0.734.

Time (TDN) had a quadratic effect on WT level modified by strong interactions with SL, DB, and EV and weak interactions with ANP. The partial derivative of WT w.r.t. TDN showed that the slope of the change in WT level per unit (days) of TDN varied with the levels of the TDN, SL, ANP, DB, and EV variables.

The final prediction model R^2 for the undrained traverse was 0.44. This R^2 was much lower than that for the undrained traverse. The final model for the undrained traverse had more significant variates. Time (TDN) had a cubic effect on WT level modified by L*L interactions with SL, ANP, DB, and EV, Q*L interactions with SL, ANP, and EV, and C*L interactions with SL and ANP.

Multiple regression analyses for undrained traverse, two groups To determine why the R^2 for the undrained prediction model was low, a stepwise procedure was used to combine soils sequentially. The R^2 values indicated that Clarion, Nicollet, and Webster (upper half of the traverse) comprised one group while Canisteo, Harps, and Okoboji (lower half of the traverse) comprised the other group. Separate regression models were developed for these two groups.

The final prediction model R^2 for the upper half was 0.60, while the final prediction model R^2 for the lower half was 0.49.

The values for WT levels at selected combinations of two variables with the others held constant were predicted from the regression equations. The effects of TDN and its interacting variables on WT level were accurate only for a time period from TDN = 110 (Apr. 20) to TDN = 260 (Sept. 17). This was done because of the obvious distortion in the relationship early and late in the year due to intercorrelations or joint effects among time of year, climatic variables of ANP and EV, and BPW.

WT level varied curvilinearly in a cubic manner with time of the year in the upper half and in a quadratic manner with the selected time period in the lower half of the traverse.

Part II

Finer textured materials above the original till, concentration of finer textured material with decreasing slope, and increasing thickness of finer textured surficial sediment with decreasing slope indicated that tile drained and undrained traverses were characterized by a systematic system of erosion and deposition. Both traverses appeared to fit into a closed erosional and depositional model.

Differences in particle size distribution were found between comparable soil series in tile drained and undrained traverses. This difference may be related to differences in weathering environments between these two sola caused by perching of water above strata high in sand. The other and more acceptable explanation relates to variability of material.

Sola of Nicollet, Webster, Canisteo, and Okoboji in the tile drained traverse contained from 4 to 10% more clay in their sola than comparable sola for these soils in the undrained traverse. Two possible hypotheses are proposed to account for these differences. First, clay differences may be related to differences in weathering environments of these soils. Differences could be caused by differences in degree of equilibrium and length of time it takes a chemical weathering environment to achieve quasi-equilibrium. A tile drained system would remove soluble weathering products at a faster rate than an undrained closed system. Faster non-equilibrium and faster weathering reactions would be associated with a tile drained system. In an undrained system where weathering products can not be leached out, a quasi-equilibrium is established quickly. The net result would be less clay formation in sola of Nicollet through Okoboji in the undrained traverse.

Second, differences in percent clay in sola of Nicollet, Webster, Canisteo, and Harps of the tile drained traverse may be caused by textural variations within the surficial sediment.

Rates of clay formation that could occur under even the most intensive weathering conditions during a period of 80 to 100 years still could not account for a 3% clay increase; therefore, the first hypothesis seems illogical. Tiling could contribute to faster rates of clay formation and translocation.

Weighted mean total phosphorus of A and B horizons, sola, and one meter zone increased with decreasing depth in both tile drained and undrained traverses. Soils in the tile drained traverse contained slightly more total phosphorus than comparable soils in the undrained traverse. These differences in total phosphorus are assumed to be caused from variability of surficial material.

Organic phosphorus and organic carbon increased with decreasing slope in both tile drained and undrained traverses. Differences in organic phosphorus and organic carbon were observed between comparable soils of tile drained and undrained traverses. These differences were caused because of differences and variability of surficial material. Eight to 100 years of tiling may be related to incipient changes in organic phosphorus and organic carbon between comparable soils of drained and undrained traverses.

No differences in pH were detected between comparable soils of tile drained nad undrained traverses.

Part III

A platinum electrode has only the ability to measure the average of all redox couples adjacent to its surface. If the surrounding system is predominantly oxidized with only a few reduced areas, electrode potentials will be interpreted as oxidized conditions. If platinum electrodes encounter predominantly reduced redox couples with only a few oxidized redox couples, electrode potentials will be interpreted as reduced environments.

As soil became dryer, electrode potentials increased and as soil became wetter, electrode potentials decreased. Within a vertical distance of 150 cm, electrode potential differences of 600 mV were measured. Generally, sharp reductions in electrode potentials were measured at a depth of 0 to 30 cm below the surface of a water table. These electrode potential (Eh) values showed oxidized conditions just above the water table became highly reduced 15 to 30 cm below the surface of a water table.

Electrode potentials changed seasonally with soil moisture and water table fluctuations. Highest electrode potentials for unsaturated conditions were recorded in August when soil environments were the dryest, while lowest electrode potential values were measured in June when soils were the wettest. Electrode potential measurements also indicated that under saturated conditions such as a permanent water table, electrode potentials were generally constant. These were interpreted as reduced conditions.

Data showed that electrode potentials in an area between the water table surface and soil surface were usually indicative of oxidized environments. Since water table surfaces became closer to the soil surface from highest to lowest landscape positions, this oxidized zone became thinner with decreasing slope. Eh values interpreted as reduced environments were not found in Clarion sola of either drained or undrained traverses, but reduced environments were measured at the 0.3 m depth in the undrained Okoboji and 0.9 m depth in drained Okoboji.

Electrode potentials correlate well with soil color values of 2 or lower and chroma of 3 or higher for both drained and undrained Clarion soils. Both Eh values and soil color of these soils indicated that water tables play little, if any, role in modifying chemical weathering environments in these Clarion soils. Data show that free iron distribution of about 0.6% throughout tends to correlate with Eh values of +400 to +600 mV.

Electrode potentials relate to water table levels and soil color for undrained Nicollet, Webster, Canisteo, Harps, and Okoboji soils. Since these soils are still forming under natural moisture regimes, electrode potentials relate.

Electrode potentials do not relate with water table levels and soil color for artificially drained Nicollet, Webster, Canisteo, Harps, and Okoboji soils. Tile drainage has created a much more oxidized environment, especially from the 0.3 to 0.9 m depth in these soils. Artificial water table levels and electrode potential values suggest soil colors are relict. Free iron contents of 0.2 to 0.6% did not relate to Eh.

Use of platinum electrodes in conjunction with a reference Calomel electrode made it possible to estimate relative differences between chemical weathering environments for soils in both tile drained and undrained Clarion toposequences.

Electrode potentials should be measured over a period of several years in order to determine their accuracy in monitoring weathering environments.

Conclusions

1. Depth to water table surfaces decreased and duration of water table increased from Nicollet to Okoboji in both tile drained and undrained traverses. Depth to water table surfaces from Nicollet to Okoboji was 0.7 m higher at equivalent positions on the hillslope in the undrained traverse. Water table levels for Clarion in both traverses were similar.
2. Methodology used to develop water table prediction equations in this study can be modified and applied to many soils in order to predict water table depth and duration.

3. A systematic pattern of erosion and deposition was found in each Clarion toposequence. Finer textured material or surficial sediment became thicker from higher to lower slope position.
4. Higher amounts of clay (weighted mean of B horizon) along the hillslope from Nicollet to Okoboji in the tile drained traverse were noted. This suggests the beginning of increased chemical weathering due to 80 to 100 years of tile drainage. It was also recognized that most of the clay differences between soil series of tile drained and undrained traverses were also due to differences in parent material.
5. Artificial drainage has modified the soil so that present morphology does not reflect drained environment. The potential for change in morphology is there and over time the morphological characterisics used in soil taxonomy could become obsolete.
6. Soil colors indicative of aquic moisture regimes, electrode potential values, and water table levels were indicative of the soil environment in the undrained Clarion traverse, but these same variables did not accurately characterize the present environment in the drained traverse.

RECOMMENDATIONS

Methodology used to develop water table prediction equations should be expanded to include in situ water table data collected during a period covering extreme climatic conditions from several paired tile drained and undrained Clarion toposequences. Replication would reduce effect of error due to variability of parent material and climate.

Variables of days between water table measurements (DB), net water (BPW), and cumulative precipitation (CP) should be deleted from initial regression equations. A variable or variables to account for lateral underground water movement should be included in initial regression equations.

Analyzing tile drainage water for soluble weathering products would help in determining differences in rates of weathering between tile drained and undrained Clarion toposequences. Thin section studies would also be beneficial in determining differences in rates of weathering between these traverses.

In order to study uniformity of parent material, petrographic analysis of silt and fine sand should be conducted.

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APPENDIX A: WATER TABLE DATA

Glossary of Terms and Variables Used in Multiple Regression Models

TRV traverse number. artificially drained Clarion toposequence = 1, undrained Clarion toposequence = 2.

SS soil series site within traverse. Clarion = 1, Nicollet = 2, Webster = 3, Canisteo = 4, Harps = 5, Okoboji = 6.

MO month of water table measurement.

Day day within month of water table measurement.

YR year of water table measurement.

TDN day number of water table measurement within year where January 1 = 1 and December 31 = 365.

WT water table measurement above base line in m.

BPW net water dropping below 1.5 m depth, (cm).

ANP antecedent precipitation. total water received at the site during a 30 day period prior to water table measurement, (cm).

CP cumulative precipitation. amount of precipitation received at the site between water table measurements, (cm).

DB days between water table measurements.

EV evapotranspiration, (cm).

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	1	11	11	77	315	4.3	0.0	9.5	0.0	7	0.0
1	1	11	18	77	322	4.3	0.0	9.4	0.1	8	0.0
1	1	11	26	77	330	4.3	0.0	2.9	1.0	6	0.0
1	1	12	3	77	337	4.8	0.0	1.4	0.0	7	0.0
1	1	12	12	77	346	5.1	0.0	2.7	1.2	9	0.0
1	1	12	19	77	353	5.1	0.0	3.2	1.0	7	0.0
1	1	12	24	77	358	5.1	0.0	2.6	0.0	5	0.0
1	1	12	30	77	364	4.9	0.0	2.2	0.0	6	0.0
1	1	1	13	78	13	4.8	0.0	2.5	1.5	14	0.0
1	1	1	20	78	13	4.3	0.0	1.5	0.0	7	0.0
1	1	2	3	78	33	4.3	0.0	1.3	1.1	11	0.0
1	1	2	10	78	41	4.3	0.0	1.3	0.0	7	0.0
1	1	2	17	78	48	4.3	0.0	2.2	1.1	7	0.0
1	1	2	27	78	58	4.3	0.0	2.6	0.5	10	0.0
1	1	3	6	78	62	4.3	0.0	2.0	0.5	7	0.0
1	1	3	13	78	72	4.3	0.0	1.9	0.7	7	0.0
1	1	3	20	78	79	4.3	0.0	1.4	0.0	7	0.0
1	1	3	27	78	86	4.3	0.0	1.3	0.1	7	0.0
1	1	4	3	78	93	4.3	0.0	1.0	0.0	7	0.0
1	1	4	10	78	100	5.2	0.0	5.4	4.6	7	0.0
1	1	4	24	78	114	5.2	7.8	12.3	7.5	14	2.3
1	1	5	1	78	121	6.2	0.0	12.2	0.1	7	1.5
1	1	5	8	78	128	6.2	0.0	12.4	2.5	7	0.9
1	1	5	14	78	134	6.3	1.4	13.2	3.2	6	1.5
1	1	5	30	78	150	6.2	0.0	7.2	1.6	16	4.1
1	1	6	6	78	157	6.2	0.0	7.2	0.0	7	1.4
1	1	6	16	78	167	6.7	0.0	4.0	2.4	10	3.7
1	1	6	26	78	177	6.7	0.0	9.7	6.5	10	3.6
1	1	7	7	78	188	5.9	0.7	13.2	4.5	11	4.9
1	1	7	17	78	198	5.7	2.1	15.6	4.3	10	4.7
1	1	8	1	78	213	5.8	1.4	15.6	7.6	14	7.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	1	8	9	78	221	5.8	0.0	8.1	0.0	8	4.0
1	1	8	22	78	234	5.2	0.0	5.6	5.3	13	5.6
1	1	9	1	78	244	5.4	0.0	13.8	8.3	9	4.1
1	1	9	15	78	258	5.4	0.0	18.8	5.3	14	4.3
1	1	9	27	78	270	6.5	0.0	10.8	5.5	12	2.0
1	1	10	6	78	279	6.4	0.0	11.7	0.9	9	0.0
1	1	10	17	78	290	6.2	0.0	7.5	1.0	11	0.0
1	1	10	25	78	298	6.1	0.0	2.4	0.5	8	0.0
1	1	11	2	78	306	6.1	0.0	2.4	0.4	8	0.0
1	1	11	12	78	316	5.9	0.0	1.8	3.7	10	0.0
1	1	11	27	78	331	6.2	0.0	4.9	2.0	15	0.0
1	1	12	12	78	346	6.0	0.0	7.3	1.0	15	0.0
1	1	12	21	78	355	5.8	0.0	2.7	1.6	9	0.0
1	1	1	8	79	8	5.6	0.0	0.2	0.2	18	0.0
1	1	1	20	79	20	5.2	0.0	2.6	2.4	12	0.0
1	1	2	12	79	43	5.4	0.0	3.9	2.5	23	0.0
1	1	3	6	79	65	5.5	0.0	2.9	2.5	22	0.0
1	1	3	27	79	86	5.7	0.0	8.6	6.6	21	0.0
1	1	4	12	79	102	6.1	0.0	10.1	3.7	31	0.0
1	1	4	23	79	113	6.5	4.0	9.5	4.2	11	2.8
1	1	5	10	79	130	6.5	2.2	9.6	2.1	17	4.1
1	1	5	28	79	148	6.2	0.0	6.0	3.1	18	4.6
1	1	6	13	79	164	6.2	4.4	10.0	7.1	30	3.9
1	1	7	25	79	206	5.6	2.3	11.2	13.2	42	6.5
1	1	8	25	79	237	5.8	1.7	30.7	30.6	31	3.4
1	1	9	29	79	272	6.3	0.0	6.6	8.4	35	9.4
1	1	10	27	79	300	6.4	0.0	10.5	10.5	28	0.0
1	1	11	24	79	328	6.3	0.0	6.4	6.4	28	0.0
1	1	12	15	79	349	6.2	0.0	2.4	0.1	21	0.0
1	1	1	26	80	26	5.4	0.0	2.6	4.5	42	0.0
1	1	2	24	80	55	5.0	0.0	1.3	1.3	29	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	1	3	16	80	75	4.6	0.0	1.5	0.8	20	0.0
1	1	4	4	80	94	4.4	0.0	3.3	2.9	19	0.0
1	1	5	17	80	137	6.3	0.0	2.1	2.7	43	3.7
1	1	6	21	80	172	6.2	2.9	16.6	17.1	35	1.2
1	1	7	19	80	200	5.5	0.0	4.5	4.5	28	6.2
1	1	8	1	80	213	5.5	0.0	4.6	0.4	13	5.2
1	1	9	1	80	244	5.4	0.0	12.4	12.4	31	1.4
1	1	10	1	80	274	5.2	0.0	6.5	6.5	30	6.2
1	2	11	11	77	315	3.5	0.0	9.5	0.0	7	0.0
1	2	11	18	77	322	3.5	0.0	9.4	0.1	8	0.0
1	2	11	26	77	330	3.5	0.0	2.9	1.0	8	0.0
1	2	12	3	77	337	4.4	0.0	1.4	0.0	7	0.0
1	2	12	12	77	346	4.5	0.0	2.7	1.2	9	0.0
1	2	12	19	77	353	4.5	0.0	3.2	1.0	7	0.0
1	2	12	24	77	358	4.5	0.0	2.6	0.0	5	0.0
1	2	12	30	77	364	4.6	0.0	2.2	0.0	6	0.0
1	2	1	13	78	13	4.5	0.0	2.5	1.5	14	0.0
1	2	1	20	78	20	4.6	0.0	1.5	0.0	7	0.0
1	2	2	3	78	33	4.8	0.0	1.3	1.1	11	0.0
1	2	2	10	78	41	4.5	0.0	1.3	0.0	7	0.0
1	2	2	17	78	48	4.5	0.0	2.2	1.1	7	0.0
1	2	2	27	78	58	4.4	0.0	2.6	0.5	10	0.0
1	2	3	6	78	62	4.4	0.0	2.0	0.5	7	0.0
1	2	3	13	78	72	4.4	0.0	1.9	0.7	7	0.0
1	2	3	20	78	79	4.5	0.0	1.4	0.0	7	0.0
1	2	3	27	78	86	5.2	0.0	1.3	0.1	7	0.0
1	2	4	3	78	93	4.7	0.0	1.0	0.0	7	0.0
1	2	4	10	78	100	4.7	0.0	5.4	4.6	7	0.0
1	2	4	24	78	114	4.9	7.8	12.3	7.5	14	2.3
1	2	5	1	78	121	5.5	0.0	12.2	0.1	7	1.5
1	2	5	8	78	128	5.2	0.0	12.4	2.5	7	0.9

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	2	5	14	78	134	4.6	1.4	13.2	3.2	6	1.5
1	2	5	30	78	150	5.2	0.0	7.2	1.6	16	4.1
1	2	6	6	78	157	5.2	0.0	7.2	0.0	7	1.4
1	2	6	16	78	167	5.1	0.0	4.0	2.4	10	3.7
1	2	6	26	78	177	5.0	0.0	9.7	6.5	10	3.6
1	2	7	7	78	188	5.0	0.7	13.2	4.5	11	4.9
1	2	7	17	78	198	5.0	2.1	15.6	4.8	10	4.7
1	2	8	1	78	213	4.8	1.4	15.6	7.6	14	7.0
1	2	8	9	78	221	4.8	0.0	3.1	0.0	8	4.0
1	2	8	22	78	234	4.4	0.0	5.6	5.3	13	5.6
1	2	9	1	78	244	4.9	0.0	13.8	8.3	9	4.1
1	2	9	15	78	258	4.2	0.0	13.8	5.3	14	4.8
1	2	9	27	78	270	3.9	0.0	10.8	5.5	12	2.0
1	2	10	6	78	277	5.5	0.0	11.7	0.9	9	0.0
1	2	10	17	78	290	5.3	0.0	7.5	1.0	11	0.0
1	2	10	25	78	298	5.2	0.0	2.4	0.5	8	0.0
1	2	11	2	78	306	5.1	0.0	2.4	0.4	6	0.0
1	2	11	12	78	316	5.3	0.0	1.8	3.7	10	0.0
1	2	11	27	78	331	5.2	0.0	4.9	2.0	15	0.0
1	2	12	12	78	346	5.3	0.0	7.3	1.0	15	0.0
1	2	12	21	78	355	4.9	0.0	2.7	1.6	9	0.0
1	2	1	8	79	8	4.8	0.0	0.2	0.2	18	0.0
1	2	1	20	79	20	4.7	0.0	2.6	2.4	12	0.0
1	2	2	12	79	43	4.5	0.0	3.9	2.5	23	0.0
1	2	3	6	79	65	4.5	0.0	2.9	2.5	22	0.0
1	2	3	27	79	86	5.0	0.0	8.6	6.6	21	0.0
1	2	4	12	79	102	5.3	0.0	10.1	3.7	31	0.0
1	2	4	23	79	113	5.5	4.0	9.5	4.2	11	2.8
1	2	5	10	79	130	5.5	2.2	9.6	2.1	17	4.1
1	2	5	28	79	148	5.2	0.0	6.0	3.1	18	4.6
1	2	6	13	79	164	4.9	4.4	10.0	7.1	30	3.9

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	2	7	25	79	206	4.8	2.3	11.2	13.2	42	6.5
1	2	8	25	79	237	5.0	1.7	30.7	30.6	31	3.4
1	2	9	29	79	272	5.5	0.0	6.6	8.4	35	9.4
1	2	10	27	79	300	5.5	0.0	10.5	10.5	23	0.0
1	2	11	24	79	328	5.3	0.0	6.4	6.4	28	0.0
1	2	12	15	79	349	5.2	0.0	2.4	0.1	21	0.0
1	2	1	26	80	26	4.6	0.0	2.6	4.5	42	0.0
1	2	2	24	80	55	5.4	0.0	1.3	1.3	29	0.0
1	2	3	16	80	75	4.7	0.0	1.5	0.8	20	0.0
1	2	4	4	80	94	4.9	0.0	3.8	2.9	19	0.0
1	2	5	17	80	137	5.2	0.0	2.1	2.7	43	3.7
1	2	6	21	80	172	5.0	2.9	16.6	17.1	35	1.2
1	2	7	19	80	200	4.4	0.0	4.5	4.5	28	6.2
1	2	8	1	80	213	4.8	0.0	4.6	0.4	13	5.2
1	2	9	1	80	244	5.0	0.0	12.4	12.4	31	1.4
1	2	10	1	80	274	5.3	0.0	6.5	6.5	30	6.2
1	3	11	11	77	315	4.5	0.0	9.5	0.0	7	0.0
1	3	11	18	77	322	4.5	0.0	9.4	0.1	8	0.0
1	3	11	26	77	330	4.2	0.0	2.9	1.0	8	0.0
1	3	12	3	77	337	4.2	0.0	1.4	0.0	7	0.0
1	3	12	12	77	346	4.6	0.0	2.7	1.2	9	0.0
1	3	12	19	77	353	4.5	0.0	3.2	1.0	7	0.0
1	3	12	24	77	358	4.5	0.0	2.6	0.0	5	0.0
1	3	12	30	77	364	4.5	0.0	2.2	0.0	6	0.0
1	3	1	13	78	13	4.5	0.0	2.5	1.5	14	0.0
1	3	1	20	78	20	4.4	0.0	1.5	0.0	7	0.0
1	3	2	3	78	33	4.3	0.0	1.3	1.1	11	0.0
1	3	2	10	78	41	4.3	0.0	1.3	0.0	7	0.0
1	3	2	17	78	48	4.3	0.0	2.2	1.1	7	0.0
1	3	2	27	78	53	4.2	0.0	2.5	0.5	10	0.0
1	3	3	6	78	62	4.2	0.0	2.0	0.5	7	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	3	3	13	78	72	4.2	0.0	1.9	0.7	7	0.0
1	3	3	20	78	79	4.2	0.0	1.4	0.0	7	0.0
1	3	3	27	78	86	4.2	0.0	1.3	0.1	7	0.0
1	3	4	3	78	93	4.5	0.0	1.0	0.0	7	0.0
1	3	4	10	78	100	4.5	0.0	5.4	4.6	7	0.0
1	3	4	24	78	114	4.6	7.8	12.3	7.5	14	2.3
1	3	5	1	78	121	4.5	0.0	12.2	0.1	7	1.5
1	3	5	8	78	128	4.5	0.0	12.4	2.5	7	0.9
1	3	5	14	78	134	4.6	1.4	13.2	3.2	6	1.5
1	3	5	30	78	150	4.6	0.0	7.2	1.6	16	4.1
1	3	6	6	78	157	4.6	0.0	7.2	0.0	7	1.4
1	3	6	16	78	167	4.5	0.0	4.0	2.4	10	3.7
1	3	6	26	78	177	4.5	0.0	9.7	6.5	10	3.6
1	3	7	7	78	188	4.5	0.7	13.2	4.5	11	4.9
1	3	7	17	78	198	4.5	2.1	15.6	4.8	10	4.7
1	3	8	1	78	213	4.5	1.4	15.6	7.6	14	7.0
1	3	8	9	78	221	4.2	0.0	8.1	0.0	8	4.0
1	3	8	22	78	234	4.2	0.0	5.6	5.3	13	5.6
1	3	9	1	78	244	4.2	0.0	13.8	8.3	9	4.1
1	3	9	15	78	258	4.0	0.0	18.8	5.3	14	4.8
1	3	9	27	78	270	4.6	0.0	10.8	5.5	12	2.0
1	3	10	6	78	279	4.5	0.0	11.7	0.9	9	0.0
1	3	10	17	78	290	4.5	0.0	7.5	1.0	11	0.0
1	3	10	25	78	298	4.5	0.0	2.4	0.5	8	0.0
1	3	11	2	78	306	4.5	0.0	2.4	0.4	8	0.0
1	3	11	12	78	316	4.5	0.0	1.8	3.7	10	0.0
1	3	11	27	78	331	4.5	0.0	4.9	2.0	15	0.0
1	3	12	12	78	346	4.5	0.0	7.3	1.0	15	0.0
1	3	12	21	78	355	4.5	0.0	2.7	1.6	9	0.0
1	3	1	8	79	8	4.4	0.0	0.2	0.2	18	0.0
1	3	1	20	79	20	4.3	0.0	2.6	2.4	12	0.0

TRV	SS	MO	DAY	YR	TON	WT	BPW	ANP	CP	DB	EV
1	3	2	12	79	43	4.3	0.0	3.9	2.5	23	0.0
1	3	3	6	79	65	4.4	0.0	2.9	2.5	22	0.0
1	3	3	27	79	86	4.5	0.0	8.6	6.6	21	0.0
1	3	4	12	79	102	4.5	0.0	10.1	3.7	31	0.0
1	3	4	23	79	113	4.6	4.0	9.5	4.2	11	2.6
1	3	5	10	79	130	4.6	2.2	9.6	2.1	17	4.1
1	3	5	28	79	148	4.5	0.0	6.0	3.1	18	4.6
1	3	6	13	79	164	4.6	4.4	10.0	7.1	30	3.9
1	3	7	25	79	206	4.5	2.3	11.2	13.2	42	6.5
1	3	8	25	79	237	4.5	1.7	30.7	30.6	31	3.4
1	3	9	29	79	272	4.7	0.0	6.6	8.4	35	9.4
1	3	10	27	79	300	4.7	0.0	10.5	10.5	28	0.0
1	3	11	24	79	328	4.6	0.0	6.4	6.4	28	0.0
1	3	12	15	79	349	4.5	0.0	2.4	0.1	21	0.0
1	3	1	26	80	26	4.4	0.0	2.6	4.5	42	0.0
1	3	2	24	80	55	4.3	0.0	1.3	1.3	29	0.0
1	3	3	16	80	75	4.4	0.0	1.5	0.8	20	0.0
1	3	4	4	80	94	4.5	0.0	3.8	2.9	19	0.0
1	3	5	17	80	137	4.5	0.0	2.1	2.7	43	3.7
1	3	6	21	80	172	4.5	2.9	16.6	17.1	35	1.2
1	3	7	19	80	200	4.5	0.0	4.5	4.5	28	6.2
1	3	8	1	80	213	4.4	0.0	4.6	0.4	13	5.2
1	3	9	1	80	244	4.6	0.0	12.4	12.4	31	1.4
1	3	10	1	80	274	4.6	0.0	6.5	6.5	30	6.2
1	4	11	11	77	315	4.2	0.0	9.5	0.0	7	0.0
1	4	11	18	77	322	4.2	0.0	9.4	0.1	8	0.0
1	4	11	26	77	330	4.2	0.0	2.9	1.0	8	0.0
1	4	12	3	77	337	4.1	0.0	1.4	0.0	7	0.0
1	4	12	12	77	346	4.4	0.0	2.7	1.2	9	0.0
1	4	12	19	77	353	4.3	0.0	3.2	1.0	7	0.0
1	4	12	24	77	358	4.3	0.0	2.6	0.0	5	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	4	12	30	77	364	4.2	0.0	2.2	0.0	6	0.0
1	4	1	13	77	13	4.1	0.0	2.5	1.5	14	0.0
1	4	1	20	78	20	4.1	0.0	1.5	0.0	7	0.0
1	4	2	3	78	33	3.8	0.0	1.3	1.1	11	0.0
1	4	2	10	78	41	4.0	0.0	1.3	0.0	7	0.0
1	4	2	17	78	48	4.0	0.0	2.2	1.1	7	0.0
1	4	2	27	78	58	3.9	0.0	2.6	0.5	10	0.0
1	4	3	6	78	62	3.9	0.0	2.0	0.5	7	0.0
1	4	3	13	78	72	3.9	0.0	1.9	0.7	7	0.0
1	4	3	20	78	79	4.2	0.0	1.4	0.0	7	0.0
1	4	3	27	78	86	4.2	0.0	1.3	0.1	7	0.0
1	4	4	3	78	93	4.2	0.0	1.0	0.0	7	0.0
1	4	4	10	78	100	4.5	0.0	5.4	4.6	7	0.0
1	4	4	24	78	114	4.3	7.8	12.3	7.5	14	2.3
1	4	5	1	78	121	4.2	0.0	12.2	0.1	7	1.5
1	4	5	8	78	128	4.2	0.0	12.4	2.5	7	0.9
1	4	5	14	78	134	4.2	1.4	13.2	3.2	6	1.5
1	4	5	30	78	150	4.3	0.0	7.2	1.6	16	4.1
1	4	6	6	78	157	4.2	0.0	7.2	0.0	7	1.4
1	4	6	16	78	167	4.2	0.0	4.0	2.4	10	3.7
1	4	6	26	78	177	4.3	0.0	9.7	6.5	10	3.6
1	4	7	7	78	188	4.1	0.7	13.2	4.5	11	4.9
1	4	7	17	78	198	4.1	2.1	15.6	4.8	10	4.7
1	4	8	1	78	213	4.1	1.4	15.6	7.6	14	7.0
1	4	8	9	78	221	3.9	0.0	8.1	0.0	8	4.0
1	4	8	22	78	234	3.9	0.0	5.6	5.3	13	5.6
1	4	9	1	78	244	4.2	0.0	13.8	8.3	9	4.1
1	4	9	15	78	258	4.1	0.0	18.8	5.3	14	4.8
1	4	9	27	78	270	4.3	0.0	10.8	5.5	12	2.0
1	4	10	6	78	279	4.2	0.0	11.7	0.9	9	0.0
1	4	10	17	78	290	4.3	0.0	7.5	1.0	11	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	4	10	25	78	298	4.3	0.0	2.4	0.5	8	0.0
1	4	11	2	78	306	4.2	0.0	2.4	0.4	8	0.0
1	4	11	12	78	316	4.3	0.0	1.8	3.7	10	0.0
1	4	11	27	78	331	4.3	0.0	4.9	2.0	15	0.0
1	4	12	12	78	346	4.2	0.0	7.3	1.0	15	0.0
1	4	12	21	78	355	4.2	0.0	2.7	1.6	9	0.0
1	4	1	8	79	8	4.1	0.0	0.2	0.2	18	0.0
1	4	1	20	79	20	4.0	0.0	2.6	2.4	12	0.0
1	4	2	12	79	43	3.9	0.0	3.9	2.5	23	0.0
1	4	3	6	79	65	4.1	0.0	2.9	2.5	22	0.0
1	4	3	27	79	86	4.2	0.0	3.6	6.6	21	0.0
1	4	4	12	79	102	4.2	0.0	10.1	3.7	31	0.0
1	4	4	23	79	113	4.3	4.0	9.5	4.2	11	2.8
1	4	5	10	79	130	4.3	2.2	9.6	2.1	17	4.1
1	4	5	28	79	148	4.0	0.0	6.0	3.1	18	4.6
1	4	6	13	79	164	4.3	4.4	10.0	7.1	30	3.9
1	4	7	25	79	206	4.2	2.3	11.2	13.2	42	6.5
1	4	8	25	79	237	4.2	1.7	30.7	30.6	31	3.4
1	4	9	29	79	272	4.4	0.0	6.6	8.4	35	9.4
1	4	10	27	79	300	4.4	0.0	10.5	10.5	28	0.0
1	4	11	24	79	328	4.3	0.0	6.4	6.4	28	0.0
1	4	12	15	79	349	4.2	0.0	2.4	0.1	21	0.0
1	4	1	26	80	26	4.1	0.0	2.6	4.5	42	0.0
1	4	2	24	80	55	4.0	0.0	1.3	1.3	29	0.0
1	4	3	16	80	75	4.2	0.0	1.5	0.8	20	0.0
1	4	4	4	80	94	4.2	0.0	3.8	2.9	19	0.0
1	4	5	17	80	137	4.3	0.0	2.1	2.7	43	3.7
1	4	6	21	80	172	4.4	2.9	16.6	17.1	35	1.2
1	4	7	19	80	200	4.2	0.0	4.3	4.5	28	6.2
1	4	8	1	80	213	4.1	0.0	4.6	0.4	13	5.2
1	4	9	1	80	244	4.3	0.0	12.4	12.4	31	1.4

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	4	10	1	80	274	4.4	0.0	6.5	6.5	30	6.2
1	5	11	11	77	315	4.0	0.0	9.5	0.0	7	0.0
1	5	11	18	77	322	3.9	0.0	9.4	0.1	8	0.0
1	5	11	26	77	330	4.0	0.0	2.9	1.0	8	0.0
1	5	12	3	77	337	4.0	0.0	1.4	0.0	7	0.0
1	5	12	12	77	346	4.1	0.0	2.7	1.2	9	0.0
1	5	12	19	77	353	3.9	0.0	3.2	1.0	7	0.0
1	5	12	24	77	358	3.9	0.0	2.6	0.0	5	0.0
1	5	12	30	77	364	3.8	0.0	2.2	0.0	6	0.0
1	5	1	13	77	13	4.0	0.0	2.5	1.5	14	0.0
1	5	1	20	78	20	3.6	0.0	1.5	0.0	7	0.0
1	5	2	3	78	33	3.6	0.0	1.3	1.1	11	0.0
1	5	2	10	78	41	3.5	0.0	1.3	0.0	7	0.0
1	5	2	17	78	48	3.5	0.0	2.2	1.1	7	0.0
1	5	2	27	78	58	3.4	0.0	2.6	0.5	10	0.0
1	5	3	6	78	62	3.4	0.0	2.0	0.5	7	0.0
1	5	3	13	78	72	3.4	0.0	1.9	0.7	7	0.0
1	5	3	20	78	79	4.0	0.0	1.4	0.0	7	0.0
1	5	3	27	78	86	3.8	0.0	1.3	0.1	7	0.0
1	5	4	3	78	93	3.7	0.0	1.0	0.0	7	0.0
1	5	4	10	78	100	4.0	0.0	5.4	4.6	7	0.0
1	5	4	24	78	114	3.9	7.6	12.3	7.5	14	2.3
1	5	5	1	78	121	4.1	0.0	12.2	0.1	7	1.5
1	5	5	8	78	128	3.9	0.0	12.4	2.5	7	0.9
1	5	5	14	78	134	3.9	1.4	13.2	3.2	6	1.5
1	5	5	30	78	150	4.0	0.0	7.2	1.6	16	4.1
1	5	6	6	78	157	3.9	0.0	7.2	0.0	7	1.4
1	5	6	16	78	167	4.0	0.0	4.0	2.4	10	3.7
1	5	6	26	78	177	4.0	0.0	9.7	6.5	10	3.6
1	5	7	7	78	188	3.8	0.7	13.2	4.5	11	4.9
1	5	7	17	78	196	3.9	2.1	15.6	4.8	10	4.7

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	5	8	1	78	213	3.8	1.4	15.6	7.6	14	7.0
1	5	8	9	78	221	3.4	0.0	8.1	0.0	8	4.0
1	5	8	22	78	234	3.3	0.0	5.6	5.3	13	5.6
1	5	9	1	78	244	4.0	0.0	13.8	8.3	9	4.1
1	5	9	15	78	258	4.0	0.0	18.8	5.3	14	4.8
1	5	9	27	78	270	4.0	0.0	10.8	5.5	12	2.0
1	5	10	6	78	279	4.0	0.0	11.7	0.9	9	0.0
1	5	10	17	78	290	3.6	0.0	7.5	1.0	11	0.0
1	5	10	25	78	298	3.9	0.0	2.4	0.5	8	0.0
1	5	11	2	78	306	3.9	0.0	2.4	0.4	8	0.0
1	5	11	12	78	316	4.1	0.0	1.8	3.7	10	0.0
1	5	11	27	78	331	4.0	0.0	4.9	2.0	15	0.0
1	5	12	12	78	346	4.0	0.0	7.3	1.0	15	0.0
1	5	12	21	78	355	3.8	0.0	2.7	1.6	9	0.0
1	5	1	8	79	8	3.8	0.0	0.2	0.2	18	0.0
1	5	1	20	79	20	3.7	0.0	2.6	2.4	12	0.0
1	5	2	12	79	43	3.6	0.0	3.9	2.5	23	0.0
1	5	3	6	79	65	3.7	0.0	2.9	2.5	22	0.0
1	5	3	27	79	86	4.1	0.0	8.5	6.6	21	0.0
1	5	4	12	79	102	4.1	0.0	10.1	3.7	31	0.0
1	5	4	23	79	113	4.1	4.0	9.5	4.2	11	2.8
1	5	5	10	79	130	4.0	2.2	9.6	2.1	17	4.1
1	5	5	28	79	148	3.9	0.0	6.0	3.1	18	4.6
1	5	6	13	79	164	4.0	4.0	10.0	7.1	30	3.9
1	5	7	25	79	206	3.7	2.3	11.2	13.2	42	6.5
1	5	8	25	79	237	3.8	1.7	30.7	30.6	31	3.4
1	5	9	29	79	272	4.0	0.0	6.6	8.4	35	9.4
1	5	10	27	79	300	4.1	0.0	10.5	10.5	28	0.0
1	5	11	24	79	328	4.2	0.0	6.4	6.4	23	0.0
1	5	12	15	79	349	3.9	0.0	2.4	0.1	21	0.0
1	5	1	26	80	26	3.8	0.0	2.6	4.5	42	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	5	2	24	80	55	3.6	0.0	1.3	1.3	29	0.0
1	5	3	16	80	75	3.9	0.0	1.5	0.8	20	0.0
1	5	4	4	80	94	4.3	0.0	3.8	2.9	19	0.0
1	5	5	17	80	137	4.4	0.0	2.1	2.7	43	3.7
1	5	6	21	80	172	4.0	2.9	16.6	17.1	35	1.2
1	5	7	19	80	200	3.6	0.0	4.5	4.5	28	6.2
1	5	8	1	80	213	3.7	0.0	4.6	0.4	13	5.2
1	5	9	1	80	244	4.1	0.0	12.4	12.4	31	1.4
1	5	10	1	80	274	4.0	0.0	6.5	6.5	30	6.2
1	6	11	11	77	315	3.9	0.0	9.5	0.0	7	0.0
1	6	11	18	77	322	3.9	0.0	9.4	0.1	8	0.0
1	6	11	26	77	330	3.9	0.0	2.9	1.0	8	0.0
1	6	12	3	77	337	3.9	0.0	1.4	0.0	7	0.0
1	6	12	12	77	346	3.9	0.0	2.7	1.2	9	0.0
1	6	12	19	77	353	4.0	0.0	3.2	1.0	7	0.0
1	6	12	24	77	358	4.0	0.0	2.6	0.0	5	0.0
1	6	12	30	77	364	3.9	0.0	2.2	0.0	6	0.0
1	6	1	13	77	13	3.9	0.0	2.5	1.5	14	0.0
1	6	1	20	78	20	3.9	0.0	1.5	0.0	7	0.0
1	6	2	3	78	33	3.9	0.0	1.3	1.1	11	0.0
1	6	2	10	78	41	3.8	0.0	1.3	0.0	7	0.0
1	6	2	17	78	48	3.8	0.0	2.2	1.1	7	0.0
1	6	2	27	78	58	3.7	0.0	2.6	0.5	10	0.0
1	6	3	6	78	62	3.7	0.0	2.0	0.5	7	0.0
1	6	3	13	78	72	3.4	0.0	1.9	0.7	7	0.0
1	6	3	20	78	79	4.0	0.0	1.4	0.0	7	0.0
1	6	3	27	78	86	4.0	0.0	1.3	0.1	7	0.0
1	6	4	3	78	93	3.9	0.0	1.0	0.0	7	0.0
1	6	4	10	78	100	4.0	0.0	5.4	4.6	7	0.0
1	6	4	24	78	114	4.0	7.8	12.3	7.5	14	2.3
1	6	5	1	78	121	3.9	0.0	12.2	0.1	7	1.5

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	6	5	3	78	128	4.0	0.0	12.4	2.5	7	0.9
1	6	5	14	78	134	4.2	1.4	13.2	3.2	6	1.5
1	6	5	30	78	150	4.0	0.0	7.2	1.6	16	4.1
1	6	6	6	78	157	4.0	0.0	7.2	0.0	7	1.4
1	6	6	16	78	167	3.9	0.0	4.0	2.4	10	3.7
1	6	6	25	78	177	3.9	0.0	9.7	6.5	10	3.6
1	6	7	7	78	188	3.9	0.7	13.2	4.5	11	4.9
1	6	7	17	78	198	3.9	2.1	15.6	4.8	10	4.7
1	6	8	1	78	213	3.9	1.4	15.6	7.6	14	7.0
1	6	8	9	78	221	3.6	0.0	8.1	0.0	8	4.0
1	6	8	22	78	234	3.6	0.0	5.6	5.3	13	5.6
1	6	9	1	78	244	3.9	0.0	13.8	8.3	9	4.1
1	6	9	15	78	258	3.9	0.0	18.8	5.3	14	4.8
1	6	9	27	78	270	4.0	0.0	10.8	5.5	12	2.0
1	6	10	6	78	279	3.9	0.0	11.7	0.9	9	0.0
1	6	10	17	78	290	4.0	0.0	7.5	1.0	11	0.0
1	6	10	25	78	298	4.0	0.0	2.4	0.5	8	0.0
1	6	11	2	78	306	3.8	0.0	2.4	0.4	8	0.0
1	6	11	12	78	316	3.8	0.0	1.8	3.7	10	0.0
1	6	11	27	78	331	3.8	0.0	4.9	2.0	15	0.0
1	6	12	12	78	346	3.8	0.0	7.3	1.0	15	0.0
1	6	12	21	78	355	3.8	0.0	2.7	1.6	9	0.0
1	6	1	8	79	8	3.0	0.0	0.2	0.2	18	0.0
1	6	1	20	79	20	3.2	0.0	2.6	2.4	12	0.0
1	6	2	12	79	43	3.7	0.0	3.9	2.5	23	0.0
1	6	3	6	79	65	4.0	0.0	2.9	2.5	22	0.0
1	6	3	27	79	86	4.0	0.0	8.6	6.6	21	0.0
1	6	4	12	79	102	3.9	0.0	10.1	3.7	31	0.0
1	6	4	23	79	113	3.9	4.0	9.5	4.2	11	2.8
1	6	5	10	79	130	3.9	2.2	9.6	2.1	17	4.1
1	6	5	28	79	148	3.9	0.0	6.0	3.1	18	4.6

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
1	6	6	13	79	164	3.8	4.4	10.0	7.1	30	3.9
1	6	7	25	79	206	4.0	2.3	11.2	13.2	42	6.5
1	6	8	25	79	237	4.0	1.7	30.7	30.6	31	3.4
1	6	9	29	79	272	4.0	0.0	6.6	8.4	35	9.4
1	6	10	27	79	300	4.2	0.0	10.5	10.5	28	0.0
1	6	11	22	7	32	0.4	0.0	6.4	6.4	28	0.0
1	6	12	15	79	304	3.9	0.0	2.4	0.1	21	0.0
1	6	1	26	80	26	3.7	0.0	2.6	4.5	42	0.0
1	6	2	24	80	55	3.9	0.0	1.3	1.3	29	0.0
1	6	3	16	80	75	3.9	0.0	1.5	0.8	20	0.0
1	6	4	4	80	94	3.9	0.0	3.8	2.9	19	0.0
1	6	5	17	80	137	3.8	0.0	2.1	2.7	43	3.7
1	6	6	21	80	172	3.9	2.9	16.6	17.1	35	1.2
1	6	7	19	80	200	3.6	0.0	4.5	4.5	28	6.2
1	6	8	1	80	213	3.7	0.0	4.6	0.4	13	5.2
1	6	9	1	80	244	3.8	0.0	12.4	12.4	31	1.4
1	6	10	1	80	274	3.2	0.0	6.5	6.5	30	6.2
2	1	11	11	77	315	2.7	0.0	9.5	0.0	7	0.0
2	1	11	18	77	322	2.7	0.0	9.4	0.1	8	0.0
2	1	11	26	77	330	2.7	0.0	2.9	1.0	8	0.0
2	1	12	3	77	337	2.7	0.0	1.4	0.0	7	0.0
2	1	12	12	77	346	2.7	0.0	2.7	1.2	9	0.0
2	1	12	19	77	353	2.7	0.0	3.2	1.0	7	0.0
2	1	12	24	77	358	2.7	0.0	2.6	0.0	5	0.0
2	1	12	30	77	364	2.7	0.0	2.2	0.0	6	0.0
2	1	1	13	78	13	2.7	0.0	2.5	1.5	14	0.0
2	1	1	20	78	20	2.7	0.0	1.5	0.0	7	0.0
2	1	2	3	78	33	2.7	0.0	1.3	1.1	11	0.0
2	1	2	10	78	41	2.7	0.0	1.3	0.0	7	0.0
2	1	2	17	78	48	2.7	0.0	2.2	1.1	7	0.0
2	1	2	27	78	58	2.7	0.0	2.6	0.5	10	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	1	3	6	78	62	2.7	0.0	2.0	0.5	7	0.0
2	1	3	13	78	72	2.7	0.0	1.9	0.7	7	0.0
2	1	3	20	78	79	2.7	0.0	1.4	0.0	7	0.0
2	1	3	27	78	86	2.7	0.0	1.3	0.1	7	0.0
2	1	4	3	78	93	2.7	0.0	1.0	0.0	7	0.0
2	1	4	10	78	100	2.7	0.0	5.4	4.6	7	0.0
2	1	4	24	78	114	3.9	7.8	12.3	7.5	14	2.3
2	1	5	1	78	121	4.5	0.0	12.2	0.1	7	1.5
2	1	5	8	78	128	4.5	0.0	12.4	2.5	7	0.9
2	1	5	14	78	134	4.7	1.4	13.2	3.2	6	1.3
2	1	5	30	78	150	4.7	0.0	7.2	1.6	16	4.1
2	1	6	6	78	157	4.6	0.0	7.2	0.0	7	1.4
2	1	6	16	78	167	4.4	0.0	4.0	2.4	10	3.7
2	1	6	26	78	177	4.4	0.0	9.7	6.5	10	3.6
2	1	7	7	78	188	4.3	0.7	13.2	4.5	11	4.9
2	1	7	17	78	198	4.1	2.1	15.6	4.8	10	4.7
2	1	8	1	78	213	3.9	1.4	15.6	7.6	14	7.0
2	1	8	9	78	221	3.8	0.0	3.1	0.0	8	4.0
2	1	8	22	78	234	3.8	0.0	5.6	5.3	13	5.6
2	1	9	1	78	244	3.8	0.0	13.8	8.3	9	4.1
2	1	9	15	78	258	4.0	0.0	18.8	5.3	14	4.8
2	1	9	27	78	270	4.7	0.0	10.8	5.5	12	2.0
2	1	1	6	78	279	4.7	0.0	11.7	0.9	9	0.0
2	1	10	17	78	290	4.5	0.0	7.5	1.0	11	0.0
2	1	10	25	78	298	4.4	0.0	2.4	0.5	8	0.0
2	1	11	2	78	306	4.3	0.0	2.4	0.4	8	0.0
2	1	11	12	78	316	4.6	0.0	1.8	3.7	10	0.0
2	1	11	27	78	331	4.6	0.0	4.9	2.0	15	0.0
2	1	12	12	78	346	4.4	0.0	7.3	1.0	15	0.0
2	1	12	21	78	355	4.2	0.0	2.7	1.6	9	0.0
2	1	1	8	79	8	4.0	0.0	0.2	0.2	18	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	1	1	20	79	20	3.9	0.0	2.5	2.4	12	0.0
2	1	2	12	79	43	3.8	0.0	3.9	2.5	23	0.0
2	1	3	6	79	65	3.7	0.0	2.9	2.5	22	0.0
2	1	3	27	79	86	3.9	0.0	8.6	2.1	21	0.0
2	1	4	12	79	102	4.4	0.0	10.1	3.1	31	0.0
2	1	4	23	79	113	5.0	4.0	9.5	1.1	11	2.8
2	1	5	10	79	130	4.9	2.2	9.6	1.7	17	4.1
2	1	5	28	79	148	4.7	0.0	6.0	1.8	18	4.7
2	1	6	2	79	153	4.6	0.0	6.8	1.1	5	1.3
2	1	6	22	79	173	4.6	4.4	11.2	10.8	20	5.4
2	1	7	26	79	207	3.9	2.3	11.1	11.1	34	4.3
2	1	8	25	79	237	3.9	1.7	30.7	30.7	31	3.4
2	1	9	29	79	272	4.1	0.0	6.6	8.4	35	9.4
2	1	10	27	79	300	4.5	0.0	10.5	10.5	28	0.0
2	1	11	24	79	328	3.5	0.0	8.6	6.4	28	0.0
2	1	12	24	79	358	3.9	0.0	2.0	2.0	31	0.0
2	1	1	26	80	26	3.7	0.0	2.6	2.6	33	0.0
2	1	2	24	80	55	3.5	0.0	1.3	1.3	29	0.0
2	1	3	16	80	75	3.7	0.0	1.5	0.8	20	0.0
2	1	4	6	80	96	4.3	0.0	3.5	2.9	21	0.0
2	1	5	17	80	137	4.7	2.9	2.1	2.7	41	3.7
2	1	6	21	80	172	4.6	0.0	16.8	17.1	35	1.2
2	1	7	19	80	200	4.4	0.0	4.5	4.5	28	6.2
2	1	8	1	80	213	3.8	0.0	4.9	0.4	13	5.2
2	1	9	1	80	244	3.9	0.0	12.4	12.4	31	1.4
2	1	10	1	80	274	3.8	0.0	6.5	6.5	30	6.2
2	2	11	11	77	315	4.1	0.0	9.5	0.0	7	0.0
2	2	11	18	77	322	4.0	0.0	9.4	0.1	8	0.0
2	2	11	26	77	330	4.3	0.0	2.9	1.0	6	0.0
2	2	12	3	77	337	4.3	0.0	1.4	0.0	7	0.0
2	2	12	12	77	346	4.3	0.0	2.7	1.2	9	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	2	12	19	77	353	4.1	0.0	3.2	1.0	7	0.0
2	2	12	24	77	358	4.2	0.0	2.6	0.0	5	0.0
2	2	12	30	77	364	4.2	0.0	2.2	0.0	6	0.0
2	2	1	13	78	13	4.1	0.0	2.5	1.5	14	0.0
2	2	1	20	78	20	4.0	0.0	1.5	0.0	7	0.0
2	2	2	3	78	33	3.6	0.0	1.3	1.1	11	0.0
2	2	2	10	78	41	3.8	0.0	1.3	0.0	7	0.0
2	2	2	17	78	48	3.8	0.0	2.2	1.1	7	0.0
2	2	2	27	78	58	3.7	0.0	2.6	0.5	10	0.0
2	2	3	6	78	62	3.7	0.0	2.0	0.5	7	0.0
2	2	3	13	78	72	3.7	0.0	1.9	0.7	7	0.0
2	2	3	20	78	79	3.5	0.0	1.4	0.0	7	0.0
2	2	3	27	78	86	3.6	0.0	1.3	0.1	7	0.0
2	2	4	3	78	93	3.6	0.0	1.0	0.0	7	0.0
2	2	4	10	78	100	3.5	0.0	5.4	4.6	7	0.0
2	2	4	24	78	114	4.4	7.8	12.3	7.5	14	2.3
2	2	5	1	78	121	4.0	0.0	12.2	0.1	7	1.5
2	2	5	8	78	128	4.3	0.0	12.4	2.5	7	0.9
2	2	5	14	78	134	4.5	1.4	13.2	3.2	6	1.5
2	2	5	30	78	150	4.5	0.0	7.2	1.6	16	4.1
2	2	6	6	78	157	4.3	0.0	7.2	0.0	7	1.4
2	2	6	16	78	167	4.2	0.0	4.0	2.4	10	3.7
2	2	6	26	78	177	4.3	0.0	9.7	6.5	10	3.6
2	2	7	7	78	188	4.2	0.7	13.2	4.5	11	4.9
2	2	7	17	78	198	4.1	2.1	15.6	4.8	10	4.7
2	2	8	1	78	213	4.2	1.4	15.6	7.6	14	7.0
2	2	8	9	78	221	3.8	0.0	8.1	0.0	8	4.0
2	2	8	22	78	234	3.3	0.0	5.6	5.3	13	5.6
2	2	9	1	78	244	3.3	0.0	13.8	8.3	9	4.1
2	2	9	15	78	258	3.7	0.0	18.8	5.3	14	4.3
2	2	9	27	78	270	4.4	0.0	10.8	5.5	12	2.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	2	10	6	78	279	4.3	0.0	11.7	0.9	9	0.0
2	2	10	17	78	290	4.4	0.0	7.5	1.0	11	0.0
2	2	10	25	78	298	4.3	0.0	2.4	0.5	8	0.0
2	2	11	2	78	306	4.2	0.0	2.4	0.4	8	0.0
2	2	11	12	78	316	4.4	0.0	1.3	3.7	10	0.0
2	2	11	27	78	331	4.4	0.0	4.9	2.0	15	0.0
2	2	12	12	78	346	4.2	0.0	7.3	1.0	15	0.0
2	2	12	21	78	355	3.9	0.0	2.7	1.6	9	0.0
2	2	1	8	79	8	4.0	0.0	0.2	0.2	18	0.0
2	2	1	20	79	20	3.9	0.0	2.6	2.4	12	0.0
2	2	2	12	79	43	3.7	0.0	3.9	2.5	23	0.0
2	2	3	6	79	65	4.2	0.0	2.9	2.5	22	0.0
2	2	3	27	79	86	4.3	0.0	8.6	2.1	21	0.0
2	2	4	12	79	102	4.4	0.0	10.1	3.1	31	0.0
2	2	4	23	79	113	4.7	4.0	9.5	1.1	11	2.8
2	2	5	10	79	130	4.7	2.2	9.6	1.7	17	4.1
2	2	5	28	79	148	4.4	0.0	6.0	1.8	18	4.7
2	2	6	2	79	153	4.4	0.0	6.8	1.1	5	1.3
2	2	6	22	79	173	4.4	4.4	11.2	10.8	20	5.4
2	2	7	26	79	207	3.9	2.3	11.1	11.1	34	4.3
2	2	8	25	79	237	3.8	1.7	30.7	30.7	31	3.4
2	2	9	29	79	272	4.0	0.0	6.6	8.4	35	9.4
2	2	10	27	79	300	4.1	0.0	10.5	10.5	30	0.0
2	2	11	24	79	328	4.2	0.0	8.6	6.4	28	0.0
2	2	12	24	79	358	4.1	0.0	2.0	2.0	1	0.0
2	2	1	26	80	26	4.0	0.0	2.6	2.6	33	0.0
2	2	2	24	80	55	3.9	0.0	1.3	1.3	29	0.0
2	2	3	16	80	75	4.0	0.0	1.5	0.8	20	0.0
2	2	4	4	80	94	4.1	0.0	3.5	2.9	21	0.0
2	2	5	17	80	137	4.2	0.0	2.1	2.7	41	3.7
2	2	6	21	80	172	4.2	0.0	16.8	17.1	35	1.2

IRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	2	7	19	80	200	4.4	0.0	4.5	4.5	28	6.2
2	2	8	1	80	213	3.9	0.0	4.9	0.4	13	5.2
2	2	9	1	80	244	3.8	0.0	12.4	12.4	31	1.4
2	2	10	1	80	274	4.0	0.0	6.5	6.5	30	6.2
2	3	11	11	77	315	4.0	0.0	9.5	0.0	7	0.0
2	3	11	18	77	322	3.9	0.0	9.4	0.1	8	0.0
2	3	11	26	77	330	3.8	0.0	2.9	1.0	8	0.0
2	3	12	3	77	337	3.8	0.0	1.4	0.0	7	0.0
2	3	12	12	77	346	3.9	0.0	2.7	1.2	9	0.0
2	3	12	19	77	353	3.8	0.0	3.2	1.0	7	0.0
2	3	12	24	77	358	3.8	0.0	2.6	0.0	5	0.0
2	3	12	30	77	364	3.7	0.0	2.2	0.0	6	0.0
2	3	1	13	78	13	3.6	0.0	2.5	1.5	14	0.0
2	3	1	20	78	20	3.4	0.0	1.5	0.0	7	0.0
2	3	2	3	78	33	3.3	0.0	1.3	1.1	11	0.0
2	3	2	10	78	41	3.2	0.0	1.3	0.0	7	0.0
2	3	2	17	78	48	3.2	0.0	2.2	1.1	7	0.0
2	3	2	27	78	58	3.1	0.0	2.6	0.5	10	0.0
2	3	3	6	78	62	3.1	0.0	2.0	0.5	7	0.0
2	3	3	13	78	72	3.1	0.0	1.9	0.7	7	0.0
2	3	3	20	78	79	3.3	0.0	1.4	0.0	7	0.0
2	3	3	27	78	86	3.7	0.0	1.3	0.1	7	0.0
2	3	4	3	78	93	3.9	0.0	1.0	0.0	7	0.0
2	3	4	10	78	100	3.2	0.0	5.4	4.6	7	0.0
2	3	4	24	78	114	3.2	7.8	12.3	7.5	14	2.3
2	3	5	1	78	121	3.6	0.0	12.2	0.1	7	1.5
2	3	5	8	78	128	3.0	0.0	12.4	2.5	7	0.9
2	3	5	14	78	134	4.1	1.4	13.2	3.2	6	1.5
2	3	5	30	78	150	3.8	0.0	7.2	1.6	16	4.1
2	3	6	6	78	157	3.7	0.0	7.2	0.0	7	1.4
2	3	6	16	78	167	3.5	0.0	4.0	2.4	10	3.7

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	3	6	26	78	177	3.9	0.7	9.7	6.5	10	3.6
2	3	7	7	78	188	3.6	2.1	13.2	4.5	11	4.9
2	3	7	17	78	198	3.6	1.4	15.6	4.8	10	4.7
2	3	8	1	78	213	3.5	0.0	15.6	7.6	14	7.0
2	3	8	9	78	221	3.3	0.0	8.1	0.0	8	4.0
2	3	8	22	78	234	3.3	0.0	5.6	5.3	13	5.6
2	3	9	1	78	244	3.4	0.0	13.8	8.3	9	4.1
2	3	9	15	78	258	3.7	0.0	18.8	5.3	14	4.3
2	3	9	27	78	270	4.0	0.0	10.8	5.5	12	2.0
2	3	10	6	78	279	3.9	0.0	11.7	0.9	9	0.0
2	3	10	17	78	290	3.8	0.0	7.5	1.0	11	0.0
2	3	10	25	78	298	3.8	0.0	2.4	0.5	8	0.0
2	3	11	2	78	306	4.1	0.0	2.4	0.4	8	0.0
2	3	11	12	78	316	4.1	0.0	1.8	3.7	10	0.0
2	3	11	27	78	346	3.6	0.0	4.9	2.0	15	0.0
2	3	12	12	78	331	4.0	0.0	7.3	1.0	15	0.0
2	3	12	21	78	355	3.7	0.0	2.7	1.6	9	0.0
2	3	1	8	79	8	4.4	0.0	0.2	0.2	18	0.0
2	3	1	20	79	20	3.3	0.0	2.6	2.4	12	0.0
2	3	2	12	79	43	4.3	0.0	3.9	2.5	23	0.0
2	3	3	6	79	65	4.2	0.0	2.9	2.5	22	0.0
2	3	3	27	79	86	4.0	0.0	8.6	2.1	21	0.0
2	3	4	12	79	102	4.0	0.0	10.1	3.1	31	0.0
2	3	4	23	79	113	4.1	4.0	9.5	1.1	11	2.8
2	3	5	10	79	130	4.0	2.2	9.6	1.7	17	4.1
2	3	5	28	79	148	3.8	0.0	6.0	1.8	18	4.7
2	3	6	2	79	153	3.8	0.0	6.8	1.1	5	1.3
2	3	6	22	79	173	3.8	4.4	11.2	10.8	20	5.4
2	3	7	26	79	207	3.5	2.3	11.1	11.1	34	4.3
2	3	8	25	79	237	3.6	1.7	30.7	30.7	31	3.4
2	3	9	29	79	272	4.0	0.0	6.6	8.4	35	9.4

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	3	10	27	79	300	4.0	0.0	10.5	10.5	28	0.0
2	3	11	24	79	328	3.8	0.0	8.6	6.4	28	0.0
2	3	12	24	79	358	3.7	0.0	2.0	2.0	30	0.0
2	3	1	26	80	26	3.7	0.0	2.6	2.6	33	0.0
2	3	2	24	80	55	3.6	0.0	1.3	1.3	29	0.0
2	3	3	16	80	75	3.8	0.0	1.5	0.8	20	0.0
2	3	4	4	80	94	4.0	0.0	3.5	2.9	21	0.0
2	3	5	17	80	137	4.0	2.9	2.1	2.7	41	3.7
2	3	6	21	80	172	3.9	0.0	15.8	17.1	35	1.2
2	3	7	19	80	200	3.8	0.0	4.5	4.5	28	6.2
2	3	8	1	80	213	3.9	0.0	4.9	0.4	13	5.2
2	3	9	1	80	244	4.0	0.0	12.4	12.4	31	1.4
2	3	10	1	80	274	4.0	0.0	6.5	6.5	30	6.2
2	4	11	11	77	315	4.1	0.0	9.5	0.0	7	0.0
2	4	11	18	77	322	4.0	0.0	9.4	0.1	8	0.0
2	4	11	26	77	330	4.0	0.0	2.9	1.0	8	0.0
2	4	12	3	77	337	4.0	0.0	1.4	0.0	7	0.0
2	4	12	12	77	346	4.0	0.0	2.7	1.2	9	0.0
2	4	12	19	77	353	4.2	0.0	3.2	1.0	7	0.0
2	4	12	24	77	358	4.1	0.0	2.6	0.0	5	0.0
2	4	12	30	77	364	3.9	0.0	2.2	0.0	6	0.0
2	4	1	13	78	13	3.7	0.0	2.5	1.5	14	0.0
2	4	1	20	78	20	3.7	0.0	1.5	0.0	7	0.0
2	4	2	3	78	33	3.6	0.0	1.3	1.1	11	0.0
2	4	2	10	78	41	3.6	0.0	1.3	0.0	7	0.0
2	4	2	17	78	48	3.6	0.0	2.2	1.1	7	0.0
2	4	2	27	78	58	3.5	0.0	2.6	0.5	10	0.0
2	4	3	6	78	62	3.5	0.0	2.0	0.5	7	0.0
2	4	3	13	78	72	3.2	0.0	1.9	0.7	7	0.0
2	4	3	20	78	79	4.1	0.0	1.4	0.0	7	0.0
2	4	3	27	78	86	4.2	0.0	1.3	0.1	7	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	4	4	3	78	93	4.3	0.0	1.0	0.0	7	0.0
2	4	4	10	78	100	4.4	0.0	5.4	4.6	7	0.0
2	4	4	24	78	114	4.1	7.5	12.3	7.5	14	2.3
2	4	5	1	78	121	4.0	0.0	12.2	0.1	7	1.5
2	4	5	8	78	128	4.1	0.0	12.4	2.5	7	0.9
2	4	5	14	78	134	4.1	1.4	13.2	3.2	6	1.5
2	4	5	30	78	150	3.9	0.0	7.2	1.6	16	4.1
2	4	6	6	78	157	3.9	0.0	7.2	0.0	7	1.4
2	4	6	16	78	167	3.8	0.0	4.0	2.4	10	3.7
2	4	6	26	78	177	4.1	0.0	9.7	6.5	10	3.6
2	4	7	7	78	188	4.0	0.7	13.2	4.5	11	4.9
2	4	7	17	78	198	3.9	2.1	15.6	4.8	10	4.7
2	4	8	1	78	213	3.8	1.4	15.6	7.6	14	7.0
2	4	8	9	78	221	3.6	0.0	8.1	0.0	3	4.0
2	4	8	22	78	234	3.6	0.0	5.6	5.3	13	5.6
2	4	9	1	78	244	3.9	0.0	13.8	8.3	9	4.1
2	4	9	15	78	258	3.6	0.0	18.8	5.3	14	4.3
2	4	9	27	78	270	4.2	0.0	10.8	5.5	12	2.0
2	4	10	6	78	279	4.0	0.0	11.7	0.9	9	0.0
2	4	10	17	78	290	4.0	0.0	7.5	1.0	11	0.0
2	4	10	25	78	298	4.0	0.0	2.4	0.5	8	0.0
2	4	11	2	78	306	4.0	0.0	2.4	0.4	8	0.0
2	4	11	12	78	316	4.2	0.0	1.8	3.7	10	0.0
2	4	11	27	78	331	4.2	0.0	4.9	2.0	15	0.0
2	4	12	12	78	346	4.0	0.0	7.3	1.0	15	0.0
2	4	12	21	78	355	4.0	0.0	2.7	1.6	9	0.0
2	4	1	8	79	8	3.6	0.0	0.2	0.2	18	0.0
2	4	1	20	79	20	3.6	0.0	2.6	2.4	12	0.0
2	4	2	12	79	43	3.5	0.0	3.9	2.5	23	0.0
2	4	3	6	79	65	3.1	0.0	2.9	2.5	22	0.0
2	4	3	27	79	86	4.3	0.0	3.6	2.1	21	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	4	4	12	79	102	4.5	0.0	10.1	3.1	31	0.0
2	4	4	23	79	113	4.3	4.0	9.5	1.1	11	2.8
2	4	5	10	79	130	4.2	2.2	9.6	1.7	17	4.1
2	4	5	28	79	148	4.0	0.0	6.0	1.8	18	4.7
2	4	6	2	79	153	4.0	0.0	0.8	1.1	5	1.3
2	4	6	22	79	173	4.0	4.4	11.2	10.8	20	5.4
2	4	7	26	79	207	3.9	2.3	11.1	11.1	34	4.3
2	4	8	25	79	237	3.8	1.7	30.7	30.7	31	3.4
2	4	9	29	79	272	4.0	0.0	6.6	8.4	35	9.4
2	4	10	27	79	300	4.0	0.0	10.5	10.5	28	0.0
2	4	11	24	79	328	3.9	0.0	8.6	6.4	28	0.0
2	4	12	24	79	356	3.9	0.0	2.0	2.0	30	0.0
2	4	1	26	80	26	3.9	0.0	2.6	2.6	33	0.0
2	4	2	24	80	55	4.0	0.0	1.3	1.3	29	0.0
2	4	3	16	80	75	4.1	0.0	1.5	0.9	20	0.0
2	4	4	6	80	96	4.2	0.0	3.5	2.9	21	0.0
2	4	5	17	80	137	4.2	2.9	2.1	2.7	41	3.7
2	4	6	21	80	172	4.2	0.0	16.8	17.1	35	1.2
2	4	7	19	80	200	4.1	0.0	4.5	4.5	28	6.2
2	4	8	1	80	213	4.1	0.0	4.9	0.4	13	5.2
2	4	9	1	80	244	4.0	0.0	12.4	12.4	31	1.4
2	4	10	1	80	274	4.0	0.0	6.5	6.5	30	6.2
2	5	11	11	77	315	4.0	0.0	9.5	0.0	7	0.0
2	5	11	18	77	322	3.9	0.0	9.4	0.1	8	0.0
2	5	11	26	77	330	3.9	0.0	2.9	1.0	8	0.0
2	5	12	3	77	337	3.9	0.0	1.4	0.0	7	0.0
2	5	12	12	77	346	3.9	0.0	2.7	1.2	9	0.0
2	5	12	19	77	353	4.2	0.0	3.2	1.0	7	0.0
2	5	12	24	77	358	4.0	0.0	2.0	0.0	5	0.0
2	5	12	30	77	364	3.9	0.0	2.2	0.0	6	0.0
2	5	1	13	78	13	3.8	0.0	2.5	1.5	14	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	5	1	20	78	20	3.7	0.0	1.5	0.0	7	0.0
2	5	2	3	78	33	3.6	0.0	1.3	1.1	11	0.0
2	5	2	10	78	41	3.6	0.0	1.3	0.0	7	0.0
2	5	2	17	78	48	3.6	0.0	2.2	1.1	7	0.0
2	5	2	27	78	58	3.6	0.0	2.6	0.5	10	0.0
2	5	3	6	78	62	3.6	0.0	2.0	0.5	7	0.0
2	5	3	13	78	72	3.6	0.0	1.9	0.7	7	0.0
2	5	3	20	78	79	3.9	0.0	1.4	0.0	7	0.0
2	5	3	27	78	86	4.3	0.0	1.3	0.1	7	0.0
2	5	4	3	78	93	4.3	0.0	1.0	0.0	7	0.0
2	5	4	10	78	100	4.4	0.0	5.4	4.5	7	0.0
2	5	4	24	78	114	4.1	7.8	12.3	7.5	14	2.3
2	5	5	1	78	121	4.0	0.0	12.2	0.1	7	1.5
2	5	5	8	78	128	4.2	0.0	12.4	2.5	7	0.9
2	5	5	14	78	134	4.1	1.4	13.2	3.2	6	1.5
2	5	5	30	78	150	3.9	0.0	7.2	1.6	16	4.1
2	5	6	6	78	157	3.8	0.0	7.2	0.0	7	1.4
2	5	6	16	78	167	3.8	0.0	4.0	2.4	10	3.7
2	5	6	26	78	177	4.0	0.0	9.7	6.5	10	3.6
2	5	7	7	78	188	3.9	0.7	13.2	4.5	11	4.9
2	5	7	17	78	198	3.7	2.1	15.6	4.8	10	4.7
2	5	8	1	78	213	3.8	1.4	15.6	7.6	14	7.0
2	5	8	9	78	221	3.6	0.0	8.1	0.0	8	4.0
2	5	8	22	78	234	3.6	0.0	5.6	5.3	13	5.6
2	5	9	1	78	244	3.9	0.0	13.8	8.3	9	4.1
2	5	9	15	78	258	3.1	0.0	18.8	5.3	14	4.8
2	5	9	27	78	270	4.0	0.0	10.8	5.5	12	2.0
2	5	10	6	78	279	4.0	0.0	11.7	0.9	9	0.0
2	5	10	17	78	290	3.8	0.0	7.5	1.0	11	0.0
2	5	10	25	78	298	4.0	0.0	2.4	0.5	8	0.0
2	5	11	2	78	306	4.0	0.0	2.4	0.4	8	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	5	11	12	78	316	4.1	0.0	1.8	3.7	10	0.0
2	5	11	27	78	331	4.1	0.0	4.9	2.0	15	0.0
2	5	12	12	78	346	4.0	0.0	7.3	1.0	15	0.0
2	5	12	21	78	355	4.0	0.0	2.7	1.6	9	0.0
2	5	1	8	79	8	3.7	0.0	0.2	0.2	18	0.0
2	5	1	20	79	20	3.7	0.0	2.6	2.4	12	0.0
2	5	2	12	79	43	3.7	0.0	3.9	2.5	23	0.0
2	5	3	6	79	65	3.9	0.0	2.9	2.5	22	0.0
2	5	3	27	79	86	4.2	0.0	8.6	2.1	21	0.0
2	5	4	12	79	102	4.3	0.0	10.1	3.1	31	0.0
2	5	4	23	79	113	4.3	4.0	9.5	1.1	11	2.8
2	5	5	10	79	130	4.1	2.2	9.6	1.7	17	4.1
2	5	5	28	79	148	4.0	0.0	6.0	1.8	18	4.7
2	5	6	2	79	153	4.0	0.0	6.8	1.1	5	1.3
2	5	6	22	79	173	4.0	4.4	11.2	10.8	20	5.4
2	5	7	26	79	207	3.9	2.3	11.1	11.1	34	4.3
2	5	8	25	79	237	3.9	1.7	30.7	30.7	31	3.4
2	5	9	29	79	272	3.9	0.0	6.6	8.4	35	9.4
2	5	10	27	79	300	3.8	0.0	10.5	10.5	28	0.0
2	5	11	24	79	328	4.0	0.0	8.6	6.4	28	0.0
2	5	12	24	79	358	4.0	0.0	2.0	2.0	30	0.0
2	5	1	26	80	26	3.9	0.0	2.6	2.6	33	0.0
2	5	2	24	80	55	4.0	0.0	1.3	1.3	29	0.0
2	5	3	16	80	75	4.0	0.0	1.5	0.8	20	0.0
2	5	4	6	80	96	4.1	0.0	3.5	2.9	21	0.0
2	5	5	17	80	137	4.0	2.9	2.1	2.7	41	3.7
2	5	6	21	80	172	3.8	0.0	15.8	17.1	35	1.2
2	5	7	19	80	200	3.7	0.0	4.5	4.5	28	6.2
2	5	8	1	80	213	3.6	0.0	4.9	0.4	13	5.2
2	5	9	1	80	244	3.6	0.0	12.4	12.4	31	1.4
2	5	10	1	80	274	3.6	0.0	6.5	6.5	30	6.2

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	6	11	11	77	315	4.0	0.0	9.5	0.0	7	0.0
2	6	11	18	77	322	3.9	0.0	9.4	0.1	8	0.0
2	6	11	26	77	330	3.9	0.0	2.9	1.0	8	0.0
2	6	12	3	77	337	3.9	0.0	1.4	0.0	7	0.0
2	6	12	12	77	346	3.9	0.0	2.7	1.2	9	0.0
2	6	12	19	77	353	3.9	0.0	3.2	1.0	7	0.0
2	6	12	24	77	358	3.9	0.0	2.6	0.0	5	0.0
2	6	12	30	77	364	3.9	0.0	2.2	0.0	6	0.0
2	6	1	13	78	13	3.3	0.0	2.5	1.5	14	0.0
2	6	1	20	78	20	3.8	0.0	1.5	0.0	7	0.0
2	6	2	3	78	33	3.7	0.0	1.3	1.1	11	0.0
2	6	2	10	78	41	3.7	0.0	1.3	0.0	7	0.0
2	6	2	17	78	48	3.0	0.0	2.2	1.1	7	0.0
2	6	2	27	78	58	3.0	0.0	2.6	0.5	10	0.0
2	6	3	6	78	62	3.1	0.0	2.0	0.5	7	0.0
2	6	3	13	78	72	3.2	0.0	1.9	0.7	7	0.0
2	6	3	20	78	79	3.3	0.0	1.4	0.0	7	0.0
2	6	3	27	78	86	4.0	0.0	1.3	0.1	7	0.0
2	6	4	3	78	93	4.1	0.0	1.0	0.0	7	0.0
2	6	4	10	78	100	4.1	0.0	5.4	4.6	7	0.0
2	6	4	24	78	114	4.1	7.8	12.3	7.5	14	2.3
2	6	5	1	78	121	4.0	0.0	12.2	0.1	7	1.5
2	6	5	8	78	128	4.0	0.0	12.4	2.5	7	0.9
2	6	5	14	78	134	4.0	1.4	13.2	3.2	6	1.5
2	6	5	30	78	150	3.9	0.0	7.2	1.6	16	4.1
2	6	6	6	78	157	3.7	0.0	7.2	0.0	7	1.4
2	6	6	16	78	167	3.6	0.0	4.0	2.4	10	3.7
2	6	6	26	78	177	3.6	0.0	9.7	6.5	10	3.6
2	6	7	7	78	188	3.6	0.7	13.2	4.5	11	4.9
2	6	7	17	78	198	3.7	2.1	15.6	4.8	10	4.7
2	6	8	1	78	213	3.5	1.4	15.6	7.6	14	7.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	6	8	9	78	221	3.6	0.0	8.1	0.0	8	4.0
2	6	8	22	78	234	3.7	0.0	5.6	5.3	13	5.0
2	6	9	1	78	244	3.6	0.0	13.8	8.3	9	4.1
2	6	9	15	78	258	3.7	0.0	18.8	5.3	14	4.8
2	6	9	27	78	270	3.9	0.0	10.8	5.5	12	2.0
2	6	10	6	78	279	3.9	0.0	11.7	0.9	9	0.0
2	6	10	17	78	290	3.7	0.0	7.5	1.0	11	0.0
2	6	10	25	78	298	3.8	0.0	2.4	0.5	8	0.0
2	6	11	2	78	306	3.8	0.0	2.4	0.4	8	0.0
2	6	11	12	78	316	3.8	0.0	1.8	3.7	10	0.0
2	6	11	27	78	331	3.7	0.0	4.9	2.0	15	0.0
2	6	12	12	78	346	3.7	0.0	7.3	1.0	15	0.0
2	6	12	21	78	355	3.7	0.0	2.7	1.6	9	0.0
2	6	1	8	79	8	3.2	0.0	0.2	0.2	18	0.0
2	6	1	20	79	20	3.3	0.0	2.6	2.4	12	0.0
2	6	2	12	79	43	3.3	0.0	3.9	2.5	23	0.0
2	6	3	6	79	65	3.4	0.0	2.9	2.5	22	0.0
2	6	3	27	79	86	3.5	0.0	8.6	2.1	21	0.0
2	6	4	12	79	102	4.2	0.0	10.1	3.1	31	0.0
2	6	4	23	79	113	4.2	4.0	9.5	1.1	11	2.8
2	6	5	10	79	130	4.1	2.2	9.6	1.7	17	4.1
2	6	5	28	79	148	4.0	0.0	6.0	1.6	18	4.7
2	6	6	2	79	153	4.0	0.0	6.8	1.1	5	1.3
2	6	6	22	79	173	4.0	4.4	11.2	10.8	20	5.4
2	6	7	26	79	207	3.8	2.3	11.1	11.1	34	4.3
2	6	8	25	79	237	3.7	1.7	30.7	30.7	31	3.4
2	6	9	29	79	272	3.9	0.0	6.6	8.4	35	9.4
2	6	10	27	79	300	3.9	0.0	10.5	10.5	28	0.0
2	6	11	24	79	328	4.0	0.0	8.6	6.4	28	0.0
2	6	12	24	79	358	4.0	0.0	2.0	2.0	30	0.0
2	6	1	26	80	26	4.0	0.0	2.6	2.6	33	0.0

TRV	SS	MO	DAY	YR	TDN	WT	BPW	ANP	CP	DB	EV
2	6	2	24	80	55	4.0	0.0	1.3	1.3	29	0.0
2	6	3	16	80	75	4.0	0.0	1.5	0.6	20	0.0
2	6	4	6	80	96	3.9	0.0	3.5	2.9	21	0.0
2	6	5	17	80	137	3.8	0.0	2.1	2.7	41	3.7
2	6	6	21	80	172	3.7	2.9	16.6	17.1	35	1.2
2	6	7	19	80	200	3.5	0.0	4.5	4.5	28	6.2
2	6	8	1	80	213	3.5	0.0	4.9	0.4	13	5.2
2	6	9	1	80	244	3.4	0.0	12.4	12.4	31	1.4
2	6	10	1	80	274	3.3	0.0	6.5	6.5	30	6.2

APPENDIX B: SOIL DESCRIPTIONS

Terminology and nomenclature used to describe soil profiles are defined in the Soil Survey Manual (Soil Survey Staff, 1951). All Munsell notations indicate moist colors. Weathering zones as outlined by Hallberg et al. (1978) are indicated in each soil profile.

Glossary of Abbreviations

Texture

Cl	clay loam
hl	heavy loam
hsl	heavy sandy loam
ltcl	light clay loam
ltl	light loam
ls	loamy sand
ltsic	light silty clay
l	loam
s	sand
sl	sandy loam

Consistence

mvfr	moist very friable
mfr	moist friable
mfi	moist firm

Reaction

e	slight
es	strong
ev	violent

Soil Color

g	gley - hues of 10 YR, 2.5 Y and 5 Y; value of 4 or higher; chroma of 2 or less

Structure

Grade: 1 = weak; 2 = moderate

Class: f = fine; m = medium

Form or type: sbk = subangular blocky; gr = granular; m = massive

Roots

Number: 1 = few; 2 = common; 3 = many

Size: vf = very fine; f = fine

Pores

Number: 1 = few; 2 = common; 3 = many

Size: vf = very fine; f = fine

Shape: v = vesicular

Mottling and stains on faces of peds

Abundance: f = few; c = common; m = many

Size: 1 = fine; 2 = medium; 3 = coarse

Contrast: f = faint; d = distinct; p = prominent

Weathering zone terminology

OU oxidized and unleached
RU reduced and unleached
UU unoxidized and unleached

Boundary

Distinctness: a = abrupt; c = clear; g = gradual

Topography: s = smooth; w = wavy

Traverse No. 1
Soil mapping unit number and percent slope: 138B, 4%
Elevation is approximately 309.7 meters
Series: Clarion
Subgroup: Typic Hapludoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Shoulder
Location: 676 m. N., 116 m. W., of NE corner of SW ¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon		Description
0-20	Ap		Black (10YR 2/1); 1tl; 1fgr to 1f sbk structure; mvfr consistence; 3f to vf roots; 2vfv pores; medium acid; as boundary
20-31	A3		Very dary grayish brown (10YR 3/2); 1tl; f1f black (10YR 2/1) stains on faces of peds; 1f sbk structure; mvfr consistence; 3f to vf roots; 2fv pores; medium acid; cs boundary
31-41	B1		Brown (10YR 4/3); sl; f1f very dark brown (10YR 2/2) stains on faces of peds; 1f sbk structure; mfr consistence; 2f to vf roots; 2fv pores; slightly acid; cw boundary
41-56	B21		Dark yellowish brown (10YR 4/4); sl; c2f very dark grayish brown (10YR 3/2) stains on faces of peds; 1 m sbk structure; mfr consistence; 2f to vf roots; 2fv pores; slightly acid; cw boundary
56-69	B22		Yellowish brown (10YR 5/4); sl; f2f very dark grayish brown (10YR 3/2) stains on faces of peds; 1 m sbk structure; mfr consistence; 1f to vf roots; 1vf pores; few fine white lime accumulations; e effervescent; neutral; cw boundary
79-107	C1	OU	Yellowish brown (10YR 5/6); 1tl; f1d dark reddish brown (5YR 3/4) mottles; m structure; mfr consistence; 1 vf roots; 3fv pores; common medium white lime seams; ev effervescent; mildly alkaline; gw boundary
107-137	C2		Yellowish brown (10YR 5/6); 1tl; f1d dark reddish brown (5 YR 3/4) and f2d light brownish gray (10YR 6/2) mottles; m structure; mfr consistence; 1vf roots; 3fv pores; common medium white lime seams; ev effervescent; mildly alkaline; gw boundary

137-183	C3	OU	Yellowish brown (10YR 5/4); ltl; c2d strong brown (7.5YR 5/6) and c3d grayish brown (10YR 5/2) mottles; m structure; mfr consistence; 3fv pores; common medium white lime seams; ev effervescent; mildly alkaline; gw boundary
183-198	C4		Same as C3(137-183) except hsl
198-295	C5		Same as C3(137-183)

Traverse No. 1
Soil mapping unit number and percent slope: 55, 2%
Elevation is approximately 308.5 meters
Series: Nicollet
Subgroup: Aquic Hapludoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Backslope
Location: 646 m. N., 116 m. W., of NE corner of SW¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (10YR 2/1); l; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; slightly acid; as boundary
20-30	A12	Black (10YR 2/1); hl; 1fsbk structure; mvfr consistence; 3f to vf roots; 2fv pores; slightly acid; cs boundary
30-51	A3	Very dark gray (10YR 3/1); hl; 2fsbk structure; mfr consistence; 3f to vf roots; 2fv pores; slightly acid; cs boundary
51-61	B1	Dark yellowish brown (10YR 4/2); ltcl; m3f very dark gray (10YR 3/1) stains on faces of peds; f1f dark grayish brown (2.5Y 4/2) mottles; 2fsbk structure; mfr consistence; 2f to vf roots; 2fv pores; slightly acid; cw boundary
61-79	B21	Dark yellowish brown (10YR 4/2); l; f2f very dark gray (10YR 3/1) stains on faces of peds; f2f dark grayish brown (2.5Y 4/2) mottles; 2fsbk structure; mfr consistence; 1f to vf roots; 1fv pores; slightly acid; cw boundary

79-89	B22		Dark grayish brown (2.5Y 4/2); l; f2f very dark grayish brown (2.5Y 3/2) stains on faces of peds; c2f dark grayish brown (2.5Y 5/2) mottles; 2fsbk structure; mfr consistence; lf roots; lfv pores; slightly acid; cw boundary
89-107	B3		Grayish brown (2.5Y 5/2); ltl; f2f very dark grayish brown (2.5Y 3/2) stains on faces of peds; fld yellowish brown (10YR 5/6) and c2f light grayish brown (2.5Y 6/2) mottles; lmsbk structure; mfr consistence; lf roots; lfv pores; neutral; gw boundary
107-122	C1		Grayish brown (2.5Y 5/2); ltl; flf dark grayish brown (2.5Y 4/2) stains on faces of peds; c2d yellowish brown (10YR 5/8) and fld black (10YR 2/1) mottles; m structure; mfr consistence; lvf roots; 2fv pores; few fine white lime accumulations; e effervescent; mildly alkaline; gw boundary
122-142	C2		Same as C1(107-122) except sl
142-173	C3	OU	Same as C1(107-122) except ls
173-203	C4		Same as C1(107-122) except sl
203-211	C5		Same as C1(107-122) except ltl
211-226	C6		Same as C1(107-122) except ls
226-241	C7		Same as C1(107-122) except ltl
241-252	C8		Same as C1(107-122) except sl
252-274	C9		Same as C1(107-122) except ltl

Traverse No. 1
Soil mapping unit number and percent slope: 107, 1%
Elevation is approximately 307.7 meters
Series: Webster
Subgroup: Typic Haplaquoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Footslope
Location: 608 m. N., 116 m. W. of NE corner of SW¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon		Description
0-20	Ap		Black (2.5Y 2/0); ltcl; lfgr structure; mvfr consistence; 3f to vf roots; 2fv pores; neutral; as boundary
20-31	A12		Black (2.5Y 2/0); cl; lfsbk structure; mfr consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
31-41	A3		Black (2.5Y 2/0); cl; fld olive gray (5Y 4/2) mottles; lfsbk structure; mfi consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
41-51	B1		Very dark grayish brown (2.5Y 3/0); ltcl; cld olive gray (5Y 4/2) mottles; 2fsbk structure; mfi consistence; 2f roots; lf to vf v pores; neutral; cs boundary
51-66	B21g		Dark gray (5Y 4/1); ltcl; mdf very dark gray (5Y 3/1) stains on faces of peds; clf olive gray (5Y 4/2) mottles; 2fsbk structure; mfi consistence; lf roots; lfv pores; neutral; cs boundary
66-76	B22g		Dark gray (5Y 4/1); ltcl; fld dark gray (2.5Y 4/0) stains on faces of peds; clf olive gray (5Y 5/2) mottles; 2fsbk structure; mfi consistence; lf roots; lfv pores; neutral; cs boundary
76-91	B31g		Gray (5Y 5/1); l; fld dark gray (2.5Y 4/0) stains on faces of peds; clf olive gray (5Y 5/2) mottles; lfsbk structure; mfi consistence; lf roots; lfv pores; e effervescence; mildly alkaline; gs boundary
91-99	B32g		Gray (5Y 5/1); ltl; fld dark gray (2.5Y 4/0) stains on faces of peds; flf yellowish brown (10YR 5/4) and flf olive gray (5Y 5/2) mottles; lfsbk structure; mfr consistence; lf roots; lfv pores; es effervescence; mildly alkaline; cs boundary
99-112	C1g		Gray (5Y 5/1); ltl; clf olive gray (5Y 5/2) and cld yellowish brown (10YR 5/4) mottles; m structure; mfr consistence; es effervence; mildly alkaline; cs boundary
112-140	C2g	RU	Same as C1g(99-112) except sl
140-155	C3g		Same as C1g(99-112) except s

155-198	C4g	Same as C1g(99-112) except sl
198-229	C5g	Same as C1g(99-112) except ltl
229-274	C6g	Same as C1g(99-112) except sl
274-310	C7g	Same as C1g(99-112) except ltl

Traverse No. 1
Soil mapping unit number and percent slope: 507, ½%
Elevation is approximately 307.4 meters
Series: Canisteo
Subgroup: Typic Haplaquoll
Family: Fine-loamy, mixed (calcareous), mesic
Hillslope position: Backslope to Footslope
Location: 584 m. N., 115 m. W. of NE corner of SW ¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (2.5Y 2/0); cl; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; e effervescence; as boundary
20-33	A1	Black (2.5Y 2/0); cl; 1fgr and 1fsbk structure; mfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; e effervescence; cs boundary
33-43	A3	Very dark gray (2.5Y 3/0); cl; c1d olive gray (5Y 4/2) mottles; 1fsbk structure; mfi consistence; 2f to vf roots; 2fv pores; mildly alkaline; e effervescence; cs boundary
43-56	B1	Very dark gray (2.5Y 3/0); ltcl; c1d olive gray (5Y 4/2) mottles; 1fsbk structure; mfi consistence; 2f roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
56-69	B21g	Dark gray (5Y 4/1); ltcl; m2f very dark gray (5Y 3/1) stains on faces of peds; c1f olive gray (5Y 4/2) mottles; 2fsbk structure; mfi consistence; 1vf roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
69-76	B22g	Dark gray (5Y 4/1); ltcl; c1f olive gray (5Y 5/2) mottles; 2fsbk structure; mfi consistence; mildly alkaline; e effervescence; cs boundary

76-89	B23g		Dark gray (5Y 4/1); ltcl; clf olive gray (5Y 5/2) and flf gray (5Y 6/1) mottles; 2fsbk structure; mfi consistence; mildly alkaline; e effervescence; cs boundary
89-97	B24g		Dark gray (5Y 4/1); ltl; clf olive gray (5Y 4/2) clf gray (5Y 6/1) mottles; lfsbk structure; mfi consistence; mildly alkaline; e effervescence; cs boundary
97-109	B31g		Gray (5Y 5/1); l; f dark gray (5Y 3/1) stains on faces of peds; clf olive gray (5Y 6/2) mottles; lfsbk structure; mfr consistence; mildly alkaline; e effervescense; cs boundary
109-127	B32g		Gray (5Y 5/1); l; flf very dark gray (5Y 3/1) stains on faces of peds; flf light olive gray (5Y 6/2) and fld light gray (5Y 7/1) mottles; lfsbk structure; cs boundary
127-137	C1g		Gray (5Y 5/1); sl; clf light olive gray (5Y 6/2), flf light gray (5Y 7/2) and fld light olive brown (2.5Y 5/6) mottles; m structure; neutral; cs boundary
137-163	C2g	RU	Gray (5Y 5/1) ltl; clf light olive gray (5Y 6/2), flf light gray (5Y 7/2) and fld light olive brown (2.5Y 5/6) mottles; m structure; neutral; cs boundary
163-252	C3g		Same as C2g(137-163) except sl;
252-267	C4g		Same as C2g(137-163) except ltl;
267-282	C5g		Same as C2g(137-163) except sl;
282-305	C6g		Same as C2g(137-163) except ltl;

Traverse No. 1
Soil mapping unit number and percent slope: 95, ½%
Elevation is approximately 307.1 meters
Series: Harps
Subgroup: Typic Calciaquoll
Family: Fine-loamy, mesic
Hillslope position: Footslope
Location: 553 m. N., 116 m. W. of NE corner of SW ¼, Sec. w, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon		Description
0-20	Apca		Black (2.5Y 2/0); hl; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; milkly alkaline; ev effervescence; as boundary
20-36	A1ca		Black (2.5Y 2/0); 1tl; f1d gray (5Y 6/0) mottles; 2fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
36-46	A3ca		Black (5Y 2.5/1); 1tcl; f1f gray (5Y 6/1) mottles; 1fsbk structure; 2f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
46-56	B1gca		Dark gray (5Y 4/1); hl; f1f gray (5Y 6/1) and f1f olive brown (2.5Y 4/4) mottles; 1fsbk structure; mfr consistence; 1f to vf roots; 2fv pores; mildly alkaline; es effervescence; cs boundary
56-66	B21g		Dark gray (5Y 4/1); hl; cmf gray (5Y 6/1) and c1d light olive brown (2.5Y 5/6) mottles; 1msbk structure; mfr consistence; 1f roots; 1fv pores; mildly alkaline; ev effervescence; cs boundary
66-76	B21g		Same as B21g(56-66) except 1tcl
76-86	B22g		Gray (5Y 5/1); hl; m2f gray (5Y 6/1) and cfd olive brown (2.5Y 5/6) mottles; 1msbk structure; mfr consistence; 1f to vf roots; mod. alkaline; ev effervescence; cs boundary
86-102	B3g		Gray (5Y 5/1); 1tl; f1f dark gray (5Y 4/1) stains; f1f light gray (5Y 7/1) and mfd olive brown (2.5Y 5/6) mottles; 1msbk structure; mfr consistence; 1f to vf roots; mod. alkaline; ev effervescence; cs boundary
102-122	C1g		Gray (5Y 5/1); 1tl; c1f light gray (5Y 7/1) and m1d light olive brown (2.5Y 5/6) mottles; m structure; mfr consistence; mildly alkaline; ev effervescence; cs boundary
122-145	C2g	RU	Same as C1g(102-122) except sl
145-160	C3g		Same as C1g(102-122) except 1s

160-173	C4g	Same as C1g(102-122)
173-219	C5g	Same as C1g(102-122) except sl
219-234	C6g	Same as C1g(102-122)
234-257	C7g	Same as C1g(102-122) except sl
257-272	C8g	Same as C1g(102-122)
272-338	C9g	Same as C1g(102-122) except sl

Traverse No. 1
Soil mapping unit number and percent slope: 6, 0%
Elevation is approximately 306.8 meters
Series: Okoboji
Subgroup: Cumulic Haplaquoll
Family: Fine, montmorillonitic, mesic
Hillslope position: Toeslope
Location: 513 m. N., 101 m. W. of NE corner of SW¼, Sec. 5, T. 83N., R. 23W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (2.5Y 2/0); ltsic; lfgr structure; mvfr consistence; 3f to vf roots; 2fv pores; neutral; as boundary
20-28	A12	Black (2.5Y 2/0); lisic; lfgr structure; mfr consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
28-36	A13	Black (2.5Y 2/0); ltsic; flf gray (2.5Y 5/0) mottles; lfsbk structure; mfi consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
36-43	A14	Black (2.5Y 2/0); cl; flf gray (2.5Y 5/0) and fld olive gray (5Y 5/2) mottles; lfsbk structure; mfi consistence; 2f to vf roots; lfv pores; neutral; cs boundary
43-51	A15	Same as A14(36-43)
51-64	A3	Black (5Y 2.5/1); ltcl; clf gray (5Y 5/1) mottles; lfsbk structure; mfi consistence; 2f roots; lfv pores; neutral; cs boundary

64-74	B1g		Black (5Y 2.5/1); ltcl; c1f gray (5Y 5/1) mottles; 2fsbk structure; mfi consistence; 2f roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
74-82	B21g		Very dark gray (5Y 3/1); ltcl; c1f gray (5Y 5/1) mottles; 2fsbk structure; mfi consistence; 1f roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
82-89	B22g		Same as B21g(74-82) except hl
89-99	B23g		Dark gray (5Y 4/1); l; c1f gray (5Y 6/1) mottles; 1fsbk structure; mfi consistence; 1f roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
99-109	B31g		Dark gray (5Y 4/1); l; c1f gray (5Y 6/1) and 1fd light olive brown (2.5Y 5/4) mottles; 1fsbk structure; mildly alkaline; es effervescence; cs boundary
109-122	B32g		Same as B31g(99-109)
122-135	B32g		Same as B31g(99-109) except ltl
135-160	C1g		Gray (5Y 5/1); ltl; c1f gray (5Y 6/1) and f1f light olive brown (2.5Y 5/4) mottles; few very dark gray (5Y 3/1) tongues; m structure; mfr consistence; mildly alkaline; es effervescence; cs boundary
160-183	C2g	RU	Gray (5Y 5/1); ltl; c1f gray (5Y 6/1) and fld light olive brown (2.5Y 5/4) mottles; fld black (5Y 2.5/1) vertical seams; m structure; mod. alkaline; ev effervescence; cs boundary
183-234	C3g		Gray (5Y 6/1); ltl; m2d yellowish brown (10YR 5/6) and fld black (2.5Y 2.5/1) mottles; m structure; mfr consistence; mod. alkaline; ev effervescence; cs boundary
234-279	C4g		Gray (5Y 6/1); ltl; c2d black (2.5Y 2/0) mottles; f1f dark gray (5Y 4/1) stains on ped faces; m structure; mfr consistence; mod. alkaline; ev effervescence; cs boundary
279-305	C5g	UU	Dark gray (5Y 4/1); ltl; c2d yellowish brown (10YR 5/6) mottles; m structure; mfi consistence; mod. alkaline; ev effervescence

Traverse No. 2
Soil mapping unit number and percent slope: 138B, 4½%
Elevation is approximately 297.1 meters
Series: Clarion
Subgroup: Typic Hapludoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Shoulder
Location: 311 m. N., 175 m. E. of SW corner of SW¼ of Sec. 21, T. 84 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (10YR 2/1); 1tl; 1fgr to 1f sbk structure; mvfr consistence; 3f to vf roots; 2fv pores; strongly acid; as boundary
20-31	A1	Very dark brown (10YR 2/2); 1tl; 1fgr to 1fsbk; mvfr consistence; 3f to vf roots; 2fv pores; strongly acid; cs boundary
31-43	A3	Very dark grayish brown (10YR 3/2); 1tl; 1fsbk; mvfr consistence; 3f to vf roots; 2fv pores; strongly acid; cs boundary
43-58	B1	Dark brown (10YR 4/3); 1tl; 1 very dark grayish brown (10YR 3/2) stains on faces of peds; 1fsbk structure; mfr consistence; 2f to vf roots; 2fv pores; strongly acid; cs boundary
58-71	B21	Dark yellowish brown (10YR 4/4); sl; 1fl dark brown (10YR 4/3) stains on faces of peds; 1fsbk structure; 2f to vf roots; 2fv pores; strongly acid; cs boundary
71-82	B21	Same as B21(58-71)
82-94	B22	Dark yellowish brown (10YR 4/4); sl; flf dark brown (10YR 4/3) stains on faces of peds; 1fsbk structure; 1f to vf roots; 2fv pores; medium acid; cs boundary
94-104	B3	Dark yellowish brown (10YR 4/4); sl; flf dark brown (10YR 3/3) stains on faces of peds; fld strong brown (7.5YR 5/6) mottles; 1msbk structure; 1f to vf roots; 1fv pores; neutral; cs boundary

104-122	C1		Yellowish brown (10YR 5/4) ltl; c1d strong brown (7.4YR 5/6) mottles; few fine white lime streaks and accumulations; m structure; mfr consistence; 1f to vf roots; 1fv pores; mildly alkaline; e effervescence; cs boundary
122-177	C2	OU	Light yellowish brown (10YR 6/4); ltl; c2d strong brown (7.5YR 5/6) mottles; few fine white lime accumulations; m structure; mfr consistence; 2fv pores; mildly alkaline; es effervescence; cs boundary
177-198	C3		Same as C2(122-177) except sl
198-229	C4		Same as C2(122-177)
229-305	C5		Same as C2(122-177) except sl

Traverse No. 2
Soil mapping unit number and percent slope: 55, 2%
Elevation is approximately 296.4 meters
Series: Nicollet
Subgroup: Aquic Hapludoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Backslope
Location: 268 m. N., 219 m. E. of SW corner of SW¼ of Sec. 21, T. 84 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (10YR 2/1); ltl; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; strongly acid; as boundary
20-31	A1	Black (10YR 2/1); l; 1fgr to 1fsbk structure; mvfr consistence; 3f to vf roots; 2fv pores; medium acid; cs boundary
31-43	A3	Very dark grayish brown (10YR 3/2); l; 1fsbk structure; mfr consistence; 3f to vf roots; 2fv pores; medium acid; cs boundary
43-58	B1	Very dark grayish brown (10YR 3/2); l; f1f black (10YR 2/1) stains on faces of peds; 1fsbk structure; mfr consistence; 3f to vf roots; 2fv pores; medium acid; cs boundary

58-74	B21		Dark yellowish brown (10YR 4/2); l; m2f dark brown (10YR 3/3) and f1f dark grayish brown (10YR 3/2) stains on faces of peds; lmsbk structure; 2f to vf roots; 2fv pores; slightly acid; cs boundary
74-84	B22		Dark brown (10YR 4/3); sl; f1f dark grayish brown (10YR 4/2) and f1d strong brown (7.5YR 5/6) mottles; lmsbk structure; mfr consistence; 2f to vf roots; 2fv pores; slightly acid; cs boundary
84-94	B3		Yellowish brown (10YR 5/4); ltl; f1f dark grayish brown (10YR 4/2) and f1d strong brown (7.5YR 5/6) mottles; lmsbk structure; mfr consistence; 2f to vf roots; 2fv pores; slightly acid; cs boundary
94-114	C1		Yellowish brown (10YR 5/4) ltl; m2d strong brown (7.5YR 5/6) and f1f very dark gray (10YR 4/1) mottles; few fine white lime accumulations; m structure; mfr consistence; lfv pores; neutral; e effervescence; cs boundary
114-264	C2	OU	Yellow brown (10YR 5/4); ltl; c2d strong brown (7.5YR 5/6) and c2d grayish brown (2.5Y 5/2) mottles; few fine white lime accumulations; m structure; mfr consistence; lfv pores; mildly alkaline; ev effervescence; cs boundary
264-292	C3		Same as C2(114-214) except sl
292-305	C4		Same as C2(114-214)

Traverse No. 2
Soil mapping unit number and percent slope: 107, 1%
Elevation is approximately 295.8 meters
Series: Webster
Subgroup: Typic Haplaquoll
Family: Fine-loamy, mixed, mesic
Hillslope position: Backslope to Footslope
Location: 250 m. N., 243 m. E. of SW corner of SW¼ of Sec. 21, T. 84 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (2.5Y 2/0); l; lfgr structure; mvfr consistence; 3f to vf roots; 2fv pores; neutral; as boundary

20-31	A1		Black (2.5Y 2/0); l; 1fgr to 1fsbk structure; mvfr consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
31-43	A3		Very dark gray (2.5Y 3/0); l; f1f dark grayish brown (2.5Y 4/2) mottles; 1fsbk structure; mfr consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
43-53	B1		Very dark gray (2.5Y 3/0); l; c1f dark grayish brown (2.5Y 4/2) mottles; 1fsbk structure; mfr consistence; 2f to vf roots; 2fv pores; neutral cs boundary
53-60	B2g		Dark gray (5Y 4/1); ltl; m2f dark olive gray (5Y 3/2) and black (5Y 2.5/2) stains on ped faces; c1f dark grayish brown (2.5Y 4/2) and f1d yellowish brown (10YR 5/6) mottles; 2fsbk structure; mfi consistence; 2f to vf roots; 2fv pores; mildly alkaline; e effervescence; cs boundary
69-76	B3g		Dark gray (5Y 4/1); ltl; f1f dark olive gray (5Y 3/2) stains on faces of peds; f1d yellowish brown (10YR 5/6) and c1f dark grayish brown (2.5Y 4/2) mottles; 2fsbk structure; mfi consistence; 2f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
76-86	B3g		Same as B3g(69-76) except sl
86-97	C1g	RU	Gray (5Y 5/1); sl texture; c1d olive gray (5Y 4/2), f1d black (5Y 2.5/1) and m2p yellowish brown (10YR 5/6) mottles; m structure; mfr consistence; 1f to vf roots; 1fv pores; mildly alkaline; ev effervescence; cs boundary
97-107	C1g		Same as C1g(86-97) except ltl
107-188	C2g		Light gray (5Y 7/1); ltl; m3p yellowish brown (10YR 5/6) and f1d black (5Y 2.5/1) mottles; m structure; mfr consistence; 1fv pores; mildly alkaline; ev effervescence; cs boundary
188-198	C3g		Same as C2g(107-188) except sl
198-208	C4g		Same as C2g(107-188)
208-218	C5g		Same as C3g(188-198)

218-229	C6g		Same as C2g(107-188)
229-262	C7g		Same as C2g(107-188) except sl
262-277	C8	UU	Dark gray (2.5Y 4/4); ltl; c2d yellowish brown (10YR 5/6) mottles; m structure; mfi consistence; mod. alkaline; ev effervescence; cs boundary
277-282	C9		Same as C8g(262-277) except sl

Traverse No. 2
Soil mapping unit number and percent slope: 507, ½%
Elevation is approximately 295.7 meters
Series: Canistea
Subgroup: Typic Haplaquoll
Family: Fine-loamy, mixed (calcareous), mesic
Hillslope position: Backslope to Footslope
Location: 238 m. N., 259 m. E., of SW corner of SW¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (2.5Y 2/0); l; lfgr structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; es effervescence; as boundary
20-31	A1	Black (2.5Y 2/0); l; lfgr to lfsbk structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; es effervescence; cs boundary
31-41	A3	Very dark gray (2.5Y 3/1); l; lfsbk structure; mfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; es effervescence; cs boundary
41-51	B1	Very dark gray (2.5Y 3/1); l; flf dark grayish brown (2.5Y 4/2) mottles; mfi consistence; 2f to vf roots; 2fv pores; mildly alkaline; es effervescence; cs boundary
51-64	B2g	Gray (5Y 5/1); l; clf dark grayish brown (2.5Y 4/2) mottles; 2msbk structure; mfi consistence; lf to vf roots; lfv pores; cs boundary
64-74	B3g	Gray (5Y 5/1); l; very dark grayish brown (2.5Y 3/2) stains on faces of peds; c2f light gray (5Y 7/2) and fld yellowish brown (10YR 5/6) mottles; lmsbk structure; mfr consistence; lf to vf roots; lfv pores; cs boundary

74-84	B3g		Same as B3g(64-74) except sl
84-99	C1g		Light olive gray (5Y 6/2); sl; c2f light gray (5Y 7/2) and f1f yellowish brown (10YR 5/6) mottles; m structure; mfr consistence; 1fv pores; cs boundary
99-109	C2g		Same as C1g(84-99) except ls
109-140	C3g		Light olive gray (5Y 6/2); sl; m2d yellowish brown (10YR 5/6) and c2f olive gray (5Y 4/2) mottles; m structure; mfr consistence; 1fv pores; cs boundary
140-150	C4g	RU	Light olive gray (5Y 6/2); ls; m2f very dark gray (5Y 3/1) and olive (5Y 5/6) mottles; m structure; mfr consistence; cs boundary
150-211	C5g		Same as C4g(140-150) except ltl
211-226	C6g		Same as C4g(140-150) except ltl
226-242	C7g		Same as C4g(140-150) except sl
242-254	C8g		Same as C4g(140-150)
254-274	C9g		Same as C4g(140-150) except sl
274-290	C10	UU	Dark gray (2.5Y 4/4); sl; c2d yellowish brown (10YR 5/6) mottles; m structure; mfi consistence; mod. alkaline; ev effervescence; cs boundary
290-305	C11		Same as C10g(274-290) except ltl

Traverse No. 2
Soil mapping unit number and percent slope: 95, ½%
Elevation is approximately 295.5 meters
Series: Harps
Subgroup: Typic Calciaquoll
Family: Fine-loamy, mesic
Hillslope position: Footslope
Location: 219 m. N., 277 m. E. of SW corner of SW¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Apca	Black (2.5Y 2/0); cl; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; ev effervescence; as boundary

20-23	A1ca		Black (2.5& 2/0); 1tcl; 1fgr to 1fsbk structure; mvfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
23-43	A3ca		Very dark gray (2.5Y 3/0); cl; mfr consistence; 3f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
43-51	B1ca		Very dark gray (5Y 3/1); cl; f1f olive gray (5Y 4/2) mottles; 2fsbk structure; mfi consistence; 2f to vf roots; 2fv pores; mildly alkaline; ev effervescence; cs boundary
51-58	B1ca		Same as B1(43-51) except 1tcl
58-69	B2g		Gray (5Y 5/1); 1tcl; m2f very dark gray (5Y 3/1) stains on faces of peds; m2f olive gray (5Y 5/2) mottles; 2fsbk structure; mfi consistence; 1f to vf roots; 1fv pores; mildly alkaline; ev effervescence; cs boundary
69-76	B2g		Same as B2g(58-69) except 1
76-89	B3g		Gray (5Y 5/1); 1; c2f olive gray (5Y 5/2) mottles; 1fsbk structure; mfi consistence; 1f to vf roots; 1fv pores; mildly alkaline; ev effervescence; cs boundary
89-104	B3g		Gray (5Y 6/1); 1tl; c2f olive gray (5Y 4/2) mottles; 1fsbk structure; mfi consistence; 1f to vf roots; 1fv pores; mildly alkaline; ev effervescence; cs boundary
104-173	C1g		Gray (5Y 6/1); 1tl; c2f olive gray (5Y 4/2) and f2d strong brown (10YR 5/6) mottles; m structure; mfi consistence; 1fv pores; mildly alkaline; ev effervescence; cs boundary
173-206	C2g		Gray (5Y 6/1); sl; c2f olive gray (5Y 4/2), f1d black (2.5Y 2/0) and f2d strong brown (10YR 5/6) mottles; m structure; mfi consistence; 1fv pores; mildly alkaline; ev effervescence; cs boundary
206-236	C3g	RU	Same as C2g(173-206) except 1s
236-249	C4g		Same as C2g(173-206)
249-264	C5g		Same as C2g(173-206) except 1tl

264-279	C6	UU	Dark gray (5Y 4/1); sl; c2d yellowish brown (10YR 5/6) mottles; m structure; mfi consistence; mod. alkaline; ev effervescence; cs boundary
279-305	C7		Same as C6(264-279) except 1tl

Traverse No. 2
Soil mapping unit number and percent slope: 6, 0%
Elevation is approximately 294.8 meters
Series: Okoboji
Subgroup: Cumulic Haplaquoll
Family: Fine, montmorillonitic, mesic
Hillslope position: Toeslope
Location: 198 m. N., 305 m. E. of SW corner of SW¼, Sec. 5, T. 83 N., R. 23 W., Story County, Iowa

Depth (cm)	Horizon	Description
0-20	Ap	Black (2.5Y 2/0); 1tcl; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; slightly acid; cs boundary
20-31	A12	Black (5Y 2.5/1); 1tcl; f1d gray (5Y 5/1) mottles; few snail shells; 1fgr structure; mvfr consistence; 3f to vf roots; 2fv pores; slightly acid; cs boundary
31-41	A13	Black (5Y 2.5/1); 1tcl; f1d gray (5Y 5/1) mottles; 1fgr structure; mfr consistence; 3f to vf roots; 2fv pores; slightly acid; cs boundary
41-51	A14	Same as A13 (31-41) except neutral
51-56	A15	Very dark gray (5Y 3/1); 1tcl; f1f gray (5Y 5/1) and (5Y 6/1) mottles; 2msbk structure; mfr consistence; 3f to vf roots; 2fv pores; neutral; cs boundary
56-71	B1	Very dark gray (5Y 3/1); 1tcl; m2d gray (5Y 6/1) mottles; 2msbk structure; mfr consistence; 2f to vf roots; 2fv pores; neutral; cs boundary
71-81	B21g	Very dark gray (5Y 3/1); 1tcl; m2f gray (5Y 6/1) and f2d yellowish brown (10YR 5/6) mottles; 1msbk structure; mfi consistence; 1f to vf roots; 1fv pores; mildly alkaline; es effervescence; cs boundary

81-102	B22g	Same as B21(71-81) except sl
102-132	B3g	Gray (5Y 5/1); ltl; m2d yellowish brown (10YR 5/6) and f1f gray (5Y 6/1) mottles; 1fmsbk structure; mfi consistence; 1fv pores; mildly alkaline; ev effervescence; cs boundary
132-163	C1g	Gray (5Y 5/1); ltl; m2d yellowish brown (10YR 5/6) and f1f gray (5Y 6/1) mottles; m structure; mfi consistence; mildly alkaline; ev effervescence; cs boundary
163-173	C2g	Same as C1g(132-163) except sl
173-183	C3g	Same as C1g(132-163)
183-203	C4g	Same as C1g(132-163) except sl
203-254	C5g	Same as C1g(132-163)
254-269	C6	Dark gray (2.5Y 4/0); ltl; c2d yellowish brown (10YR 5/6) mottles; m structure; mfi consistence; mod. alklaine; ev effervescence

APPENDIX C: PARTICLE SIZE DATA

Glossary of Terms

TRV	traverse number. artificially drained Clarion toposequence = 1, undrained Clarion toposequence = 2.
SS	soil series site within traverse. Clarion = 1, Nicollet = 2, Webster = 3, Canisteo = 4, Harps = 5, Okoboji = 6.
HORIZON	soil horizon.
DEPTH	depth of soil horizon (cm).
VCS	very coarse sand (%).
CS	coarse sand (%).
MS	medium sand (%).
FS	fine sand (%).
VFS	very fine sand (%).
TOTALS	total sand (%).
CSILT	coarse silt (%).
FSILT	fine silt (%).
TOTSILT	total silt (%).
CLAY	clay (%)
TEXTURE	USDA texture. LL = light loam (= to or 20% clay), L = loam, HL = heavy loam (= to or 25% clay), SL = sandy loam, LCL = light clay loam (27 to 30.9% clay), CL = clay loam, LS = loamy sand, LSiC = light silty clay (40 to 44% clay), SiCl = silty clay loam (44% clay)

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
1	1	AP	0-20	1.1	4.4	13.5	13.2	11.3	43.5	23.6	15.8	39.4	17.1	L
1	1	A3	20-31	2.5	6.3	15.2	14.7	12.2	49.1	20.9	12.5	33.4	15.7	L
1	1	B1	31-41	2.9	6.0	14.5	15.0	12.0	50.4	18.1	14.2	32.3	17.3	L
1	1	B21	41-56	4.5	6.9	16.3	14.7	11.5	53.9	18.1	13.9	32.0	14.1	SL
1	1	B22	56-69	3.4	7.2	16.6	13.5	12.6	53.3	20.0	13.3	33.3	13.4	SL
1	1	B3	69-79	4.4	7.5	15.2	13.3	12.1	52.5	18.0	18.5	36.5	11.0	SL
1	1	C1	79-92	4.3	7.2	14.4	12.2	11.7	49.8	22.4	19.4	41.8	8.4	L
1	1	C1	92-107	2.9	6.9	14.7	13.4	12.2	50.1	22.4	19.0	41.4	8.5	L
1	1	C2	107-122	3.0	6.6	15.2	13.6	12.4	50.4	19.4	18.5	37.9	11.3	L
1	1	C2	122-137	3.1	6.8	15.5	13.6	12.2	51.2	18.6	19.8	38.4	10.4	L
1	1	C3	137-152	3.7	6.7	15.1	13.6	12.5	51.6	16.9	19.9	36.8	11.6	L
1	1	C3	152-166	3.3	6.5	14.7	13.6	13.0	51.1	16.9	20.8	37.7	11.2	L
1	1	C3	168-183	1.6	6.8	15.4	14.4	12.9	51.3	18.5	20.3	38.8	9.9	L
1	1	C4	183-198	5.1	8.2	14.2	13.2	12.0	52.7	18.5	18.5	37.0	10.3	SL
1	1	C5	198-213	2.7	6.0	14.6	14.1	13.2	50.6	19.1	19.0	38.1	11.3	L
1	1	C5	213-229	3.8	6.5	14.0	14.0	13.1	51.4	17.6	19.0	36.6	12.0	L
1	1	C5	229-244	2.6	6.3	14.5	14.4	13.1	50.8	17.4	20.0	37.4	11.8	L
1	1	C5	244-259	3.0	7.7	14.3	14.3	12.5	51.8	20.5	16.0	36.5	11.7	L
1	1	C5	259-274	2.1	6.6	14.0	14.2	13.3	50.2	18.3	20.3	38.6	11.2	L
1	1	C5	274-295	3.4	6.6	14.3	13.7	13.3	51.3	21.7	15.1	36.8	11.9	L
1	2	AP	0-20	0.6	4.7	13.6	12.3	8.0	39.4	19.7	19.1	38.8	23.8	L
1	2	A12	20-30	1.2	4.5	10.1	9.9	7.4	33.1	20.0	21.0	41.0	25.9	HL
1	2	A3	30-51	1.7	5.1	10.6	10.9	7.9	36.2	19.1	18.8	37.9	25.9	HL
1	2	B1	51-61	1.4	5.1	13.7	13.2	9.5	42.9	6.6	23.3	29.9	27.2	L CL
1	2	B21	61-79	1.9	4.4	11.4	10.1	8.8	36.6	19.0	20.2	39.2	24.2	L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
1	2	B22	79-89	1.6	3.9	10.9	11.1	10.6	38.1	17.4	20.1	37.5	24.4	L
1	2	B3	89-107	2.3	5.4	14.4	14.1	13.1	49.3	17.4	15.2	32.6	18.1	L L
1	2	C1	107-122	4.1	5.0	9.5	9.5	11.3	39.4	29.3	17.9	47.2	13.4	L L
1	2	C2	122-132	9.7	3.3	21.3	14.4	8.4	67.1	13.6	9.9	23.5	9.4	SL
1	2	C2	132-142	6.1	1.2	18.0	15.1	14.5	64.9	16.8	9.5	23.3	8.8	SL
1	2	C3	142-158	3.7	0.6	24.5	23.1	14.3	76.2	11.4	6.8	18.2	5.6	LS
1	2	C3	158-173	6.9	4.4	29.1	18.9	17.8	77.1	10.7	7.1	17.8	5.1	LS
1	2	C4	173-188	3.6	8.9	18.3	14.3	16.9	62.0	13.6	16.3	29.9	8.2	SL
1	2	C4	188-203	3.6	9.3	19.0	17.0	13.1	62.0	17.1	13.3	30.4	7.6	SL
1	2	C5	203-211	3.4	6.8	12.6	10.7	15.7	49.2	32.6	9.3	41.9	8.9	L L
1	2	C6	211-226	5.3	9.4	18.8	18.2	19.0	70.7	14.3	8.8	23.1	6.2	LS
1	2	C7	222-241	1.6	3.2	7.4	9.7	14.2	36.1	31.4	22.6	53.7	9.9	L L
1	2	C8	241-252	4.4	8.5	14.7	16.8	13.9	58.3	16.9	15.5	32.0	9.7	SL
1	2	C9	252-264	3.3	7.3	13.5	14.7	10.0	48.8	16.5	19.6	36.1	15.1	L L
1	2	C9	264-274	2.8	5.8	13.2	13.0	10.2	46.0	13.9	20.2	34.1	19.9	L L
1	3	AP	0-20	0.6	2.9	7.8	8.1	6.3	25.7	22.0	22.1	44.1	30.2	L CL
1	3	A12	20-31	0.2	3.4	8.5	6.2	6.3	24.6	22.4	21.6	43.0	31.4	CL
1	3	A3	31-41	1.1	3.4	7.9	7.5	4.6	24.5	22.4	21.3	43.7	31.8	CL
1	3	B1	41-51	1.0	3.6	8.4	7.6	7.2	27.8	23.1	19.0	42.1	30.1	L CL
1	3	B21G	51-66	2.1	4.0	7.3	6.6	5.3	25.3	29.9	14.2	44.1	30.6	L CL
1	3	B22G	66-76	1.5	4.1	10.2	7.4	7.5	30.7	19.0	23.0	42.0	27.3	L CL
1	3	B31G	76-91	0.9	5.3	12.5	10.3	12.0	41.0	20.3	18.2	38.5	20.5	L
1	3	B32G	91-99	1.6	4.8	11.4	10.0	12.5	39.9	18.9	21.5	40.4	19.7	L L
1	3	C1G	99-112	2.3	6.0	13.8	12.1	13.8	48.0	10.9	22.0	32.9	19.1	L L
1	3	C2G	112-125	3.3	7.1	14.4	14.4	14.2	53.4	14.5	15.2	29.7	16.9	SL

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTALS	CSILT	FSILT	TOTSILT	CLAY	TEXTURE
1	3	C2G	125-140	3.3	7.5	18.8	16.8	13.2	59.6	13.7	12.1	25.8	14.6	SL
1	3	C3G	140-155	3.4	2.1	34.0	25.0	14.3	38.8	6.3	0.6	6.9	4.2	S
1	3	C4G	155-168	3.0	7.0	16.3	10.9	17.7	54.9	17.7	14.1	31.8	13.3	SL
1	3	C4G	168-183	4.7	8.3	16.9	14.5	14.1	58.5	14.6	13.9	28.5	13.0	SL
1	3	C4G	183-198	4.3	7.9	17.2	14.9	15.2	59.5	14.3	13.1	27.4	13.1	SL
1	3	C5G	198-213	2.5	6.5	14.3	13.2	15.2	51.7	17.0	15.9	32.9	15.4	L L
1	3	C5G	213-229	2.8	6.5	14.4	12.5	15.1	51.3	17.6	15.7	33.3	15.4	L L
1	3	C6G	229-244	2.3	6.5	16.5	14.1	13.6	53.0	16.2	15.4	31.6	15.4	SL
1	3	C6G	244-259	4.7	7.8	14.6	12.4	12.9	52.4	17.6	14.6	32.2	15.4	SL
1	3	C6G	259-274	2.3	6.3	16.3	13.6	18.6	57.1	7.4	18.3	25.7	17.2	SL
1	3	C7G	274-290	1.2	6.7	14.0	12.7	15.6	50.2	17.0	17.2	34.2	15.6	L L
1	3	C7G	290-310	2.1	6.5	14.4	15.5	12.3	50.9	16.2	17.6	33.8	15.3	L L
1	3	C7G	310-325	2.5	5.8	14.2	12.2	15.3	50.0	17.5	16.5	34.0	16.0	L L
1	3	C7G	325-338	3.0	6.7	14.8	12.7	14.1	51.3	15.9	17.8	33.7	15.0	L L
1	4	AP	0-20	0.3	3.1	7.0	5.8	8.9	25.2	14.4	26.1	40.5	34.3	CL
1	4	A1	20-33	0.3	3.0	8.1	5.6	9.4	26.4	15.2	24.3	39.5	34.1	CL
1	4	A3	33-43	1.3	4.0	9.4	6.7	9.7	31.1	14.1	23.2	37.3	31.6	CL
1	4	B1	43-56	1.0	3.9	10.7	8.2	8.8	32.6	17.2	20.2	37.4	30.0	L CL
1	4	B21G	56-69	0.9	4.3	10.2	8.6	10.0	34.0	14.7	22.1	36.8	29.2	L CL
1	4	B22G	69-76	1.4	4.3	10.7	8.0	9.6	34.0	14.8	23.1	37.9	28.1	L CL
1	4	B23G	76-89	0.8	3.6	10.0	8.9	10.4	33.7	14.2	21.3	35.5	30.8	L CL
1	4	B24G	89-97	0.7	4.0	9.8	8.0	10.5	33.0	14.9	21.0	35.9	31.1	L CL
1	4	B31G	97-109	1.6	5.1	14.0	12.1	12.4	45.5	14.3	15.6	29.9	24.6	L
1	4	B32G	109-117	1.5	5.8	15.0	13.2	11.9	47.4	12.7	16.2	28.9	23.7	L
1	4	B32G	117-127	3.6	6.5	14.5	12.2	12.6	49.4	12.6	15.1	27.7	22.9	L

TPV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOTSILT	CLAY	TEXTURE
1	4	C1G	127-137	2.1	5.9	15.8	15.0	13.4	52.2	12.5	14.1	26.6	21.2	SL
1	4	C2G	137-147	2.2	6.4	15.0	13.0	11.9	48.5	11.4	16.3	27.7	23.8	L
1	4	C2G	147-163	2.5	6.9	15.9	17.6	11.6	54.5	12.8	13.1	25.9	19.6	L
1	4	C3G	163-173	2.3	6.9	16.6	16.9	15.8	58.5	9.6	14.0	23.6	17.9	SL
1	4	C3G	173-183	2.4	6.4	15.9	14.0	15.1	53.8	11.7	16.4	28.1	18.1	SL
1	4	C3G	183-198	2.1	7.6	15.5	15.8	16.1	57.1	13.4	14.9	28.3	14.6	SL
1	4	C3G	198-214	2.3	7.4	15.2	13.7	14.9	53.5	14.7	14.5	29.2	17.3	SL
1	4	C4G	214-229	1.2	7.2	13.2	13.0	15.6	52.2	16.8	15.5	32.3	15.5	SL
1	4	C4G	229-236	1.9	5.8	15.7	13.4	15.3	52.6	15.5	17.0	32.5	14.9	SL
1	4	C4G	236-252	2.8	6.3	14.6	12.6	15.4	52.2	16.8	16.5	33.3	14.5	SL
1	4	C4G	252-267	2.5	6.2	15.0	13.0	15.0	51.7	15.9	16.2	32.1	16.2	L L
1	4	C4G	267-282	2.4	6.1	14.6	13.0	16.3	52.4	14.9	17.6	32.5	15.1	SL
1	4	C4G	282-305	1.7	6.7	14.5	12.4	16.4	51.7	15.4	17.9	33.3	15.0	L L
1	5	APCA	0-20	0.2	4.3	10.3	9.9	7.0	33.3	17.4	21.1	38.5	28.2	HL
1	5	A1CA	20-36	0.2	3.7	9.7	8.9	4.0	31.0	16.5	23.0	39.5	29.5	L CL
1	5	A3CA	36-46	0.5	3.2	8.8	8.2	5.6	31.9	15.6	24.1	39.7	28.4	L CL
1	5	B1GC	46-56	0.8	2.8	8.1	8.6	5.6	31.4	16.4	24.2	40.5	28.0	L CL
1	5	B21G	56-66	0.6	2.6	7.5	8.0	3.3	29.5	19.2	25.1	44.3	26.2	HL
1	5	B21G	66-76	0.7	2.5	7.8	8.1	4.9	25.7	17.7	28.1	45.8	28.5	L CL
1	5	B22G	76-86	0.6	2.8	8.2	9.9	6.2	29.9	18.2	26.4	44.6	25.5	HL
1	5	B3G	86-94	1.4	3.9	9.7	12.4	18.6	46.0	17.5	19.6	37.1	16.9	L L
1	5	B3G	94-102	2.7	3.8	7.6	11.2	10.4	41.2	23.0	19.4	42.4	16.4	L L
1	5	C1G	102-112	0.9	2.5	7.4	11.4	15.7	37.4	25.7	25.0	50.7	16.4	L L
1	5	C1G	112-122	2.0	2.8	6.3	8.7	16.3	35.5	23.6	21.9	47.5	17.0	L L
1	5	C2G	122-137	3.2	6.6	15.4	20.8	21.7	68.0	7.8	13.0	20.8	11.2	SL

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTALS	CSILT	FSILT	TOTSILT	CLAY	TEXTURE
1	5	C2G	137-145	3.1	7.7	23.0	21.9	14.4	69.5	12.4	9.3	21.7	8.8	SL
1	5	C3G	145-160	4.6	1.0	26.4	19.4	11.8	77.2	12.6	7.1	19.7	3.1	LS
1	5	C4G	160-173	2.4	6.0	13.3	11.8	16.4	50.4	21.3	17.1	38.4	11.2	L L
1	5	C5G	173-188	3.2	7.0	15.4	14.2	20.2	59.8	13.4	15.3	28.7	11.5	SL
1	5	C5G	188-203	5.3	8.7	15.4	13.5	17.3	59.8	12.0	16.2	28.2	12.0	SL
1	5	C5G	203-219	1.7	5.8	10.4	11.5	27.5	57.0	17.6	15.3	32.9	10.1	SL
1	5	C6G	219-234	1.0	3.3	6.9	7.4	23.2	41.3	35.4	14.4	49.8	8.9	L L
1	5	C7G	234-249	3.5	6.9	13.0	12.1	18.1	53.6	16.0	18.6	34.6	11.8	SL
1	5	C7G	249-257	3.2	8.1	16.8	15.2	16.8	61.1	11.6	15.7	27.3	11.6	SL
1	5	C8G	257-272	2.9	6.0	14.1	14.1	13.5	50.3	19.0	14.0	33.0	16.7	L L
1	5	C9G	272-287	3.0	6.2	14.7	13.4	16.4	53.7	15.8	15.1	30.9	15.4	SL
1	5	C9G	287-300	3.0	6.4	14.9	14.1	16.8	55.3	13.3	16.6	29.9	14.8	SL
1	5	C9G	300-307	2.7	5.9	14.7	14.1	15.8	53.0	17.7	15.5	33.2	13.8	SL
1	5	C9G	307-323	2.7	6.6	15.5	14.2	15.0	53.6	15.3	16.9	32.2	14.2	SL
1	5	C9G	323-338	1.5	5.9	14.8	14.8	14.7	52.6	15.0	16.8	31.8	15.6	SL
1	6	AP	0-20	0.3	1.6	3.5	2.8	3.8	12.0	13.6	32.3	45.9	42.1	L SIC
1	6	A12	20-28	0.0	1.4	3.6	3.3	4.2	12.1	11.6	32.4	44.0	43.9	L SIC
1	6	A13	28-36	0.3	1.8	4.1	4.2	6.4	17.5	12.8	29.0	41.8	40.7	L SIC
1	6	A14	36-43	0.4	2.5	6.4	6.9	8.0	24.2	15.9	27.2	43.1	32.7	CL
1	6	A15	43-51	0.4	2.7	8.0	7.3	9.4	28.4	14.2	24.5	38.7	32.9	CL
1	6	A3	51-64	0.6	2.6	8.9	8.2	5.1	26.0	11.3	33.2	44.5	29.5	L CL
1	6	B1G	64-74	0.1	2.1	8.2	8.1	5.7	24.8	14.2	31.4	45.6	29.6	L CL
1	6	B21G	74-82	0.4	3.1	8.9	7.7	7.2	28.2	12.6	29.2	67.0	30.0	L CL
1	6	B22G	82-89	0.9	4.3	10.0	8.7	7.3	30.7	17.2	25.9	43.1	26.2	HL
1	6	B23G	89-99	2.2	5.3	11.6	10.6	8.8	37.6	18.1	23.9	42.0	20.4	L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
1	6	B31G	99-109	2.5	5.2	0.9	11.3	10.7	41.3	13.0	24.6	37.6	21.1	L
1	6	B32G	109-122	2.1	5.3	12.0	11.2	9.4	40.2	14.6	24.5	39.1	20.7	L
1	6	B32G	122-135	2.3	6.1	14.2	13.0	11.4	47.0	14.1	20.8	34.9	17.5	L L
1	6	C1G	135-147	2.1	5.5	11.6	10.9	10.5	44.2	12.3	24.3	36.6	19.1	L L
1	6	C1G	147-160	4.2	0.0	23.0	22.0	20.0	49.7	15.6	13.2	33.8	16.5	L L
1	6	C2G	160-173	1.7	6.6	15.5	14.3	12.7	51.5	17.7	16.4	34.1	14.4	L L
1	6	C2G	173-183	2.4	7.6	14.8	24.0	11.9	50.6	9.1	27.6	36.7	12.7	L L
1	6	C3G	183-198	1.9	6.7	14.7	14.2	13.0	50.6	19.6	17.2	36.8	12.6	L L
1	6	C3G	198-214	1.6	6.6	15.1	14.0	12.6	50.2	17.3	18.3	35.6	14.2	L L
1	6	C3G	214-224	3.0	6.9	15.2	13.8	12.6	51.5	15.2	20.8	36.0	12.5	L L
1	6	C3G	224-234	2.5	6.9	15.6	14.0	12.5	51.2	17.6	19.8	37.4	11.4	L L
1	6	C4G	234-249	2.6	7.0	15.3	13.7	12.5	51.5	14.8	19.4	34.2	14.3	L L
1	6	C4G	249-264	2.4	8.2	16.1	14.2	11.2	51.9	17.2	17.4	34.6	13.5	L L
1	6	C4G	264-279	2.6	6.5	15.6	13.8	12.0	51.1	12.0	24.0	35.0	12.5	L L
1	6	C5G	279-292	8.1	6.0	15.2	13.3	12.4	50.4	18.8	15.9	34.7	14.9	L L
1	6	C5G	292-305	2.6	6.0	14.9	13.5	9.0	46.8	18.5	21.0	39.5	13.7	L L
2	1	AP	0-20	0.7	5.0	15.4	14.5	11.4	47.4	14.6	20.1	34.7	17.9	L L
2	1	A1	20-31	0.3	5.9	13.4	15.2	13.5	46.3	15.7	19.9	35.6	18.1	L L
2	1	A3	31-43	0.5	3.6	14.3	16.0	11.2	49.6	15.1	16.6	31.7	18.7	L L
2	1	B1	43-58	0.5	3.7	13.6	16.1	15.4	49.3	21.9	12.9	34.8	15.9	L L
2	1	B21	58-71	2.3	8.1	19.8	18.8	10.5	60.0	11.3	12.7	24.0	16.0	SL
2	1	B21	71-82	4.9	9.9	17.3	15.6	14.4	62.6	9.7	13.5	23.2	14.2	SL
2	1	B22	82-94	4.1	8.7	16.9	15.8	14.7	60.2	12.2	14.5	26.7	13.1	SL
2	1	B3	94-104	4.2	8.9	15.7	16.4	16.7	61.9	13.2	13.0	26.2	11.9	SL
2	1	C1	104-117	[illegible]	5.1	14.3	15.1	13.3	48.7	12.1	23.3	35.4	15.9	L L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTALS	CSILT	FSILT	TOTSILT	CLAY	TEXTURE
2	1	C1	117-122	2.1	6.1	17.0	16.5	7.5	51.2	14.7	25.4	40.1	8.7	L L
2	1	C2	122-138	2.3	6.2	14.6	14.3	12.0	49.1	14.3	25.3	39.6	11.3	L L
2	1	C2	138-152	2.2	7.6	17.0	15.7	12.8	55.3	13.3	20.8	34.1	10.6	L L
2	1	C2	152-177	1.4	6.6	17.4	15.1	14.2	54.7	13.3	21.0	34.3	11.0	L L
2	1	C3	177-183	4.0	7.7	16.2	15.0	10.2	53.1	14.4	21.2	35.3	11.3	SL
2	1	C3	183-198	3.6	7.1	15.7	14.5	12.7	53.9	12.7	21.2	33.9	12.2	SL
2	1	C4	198-213	2.7	3.7	16.1	13.9	13.1	49.5	12.6	23.2	35.8	14.7	L L
2	1	C4	213-229	3.3	6.9	16.2	14.4	10.6	51.4	15.1	19.7	34.9	13.8	L L
2	1	C5	229-244	5.3	8.3	15.6	13.7	10.4	54.3	11.3	21.6	32.9	12.8	SL
2	1	C5	244-254	5.2	7.0	15.6	14.0	11.1	52.9	12.6	21.8	34.4	12.7	SL
2	1	C5	254-269	4.0	7.1	15.7	14.6	10.7	52.6	12.7	21.9	34.2	13.2	SL
2	1	C5	269-285	4.0	7.3	15.7	14.1	11.7	52.8	15.6	18.7	34.3	12.9	SL
2	1	C5	285-300	3.8	7.9	15.6	13.7	11.7	52.7	16.0	18.3	34.3	13.0	SL
2	1	C5	300-305	3.7	8.0	15.4	13.6	11.8	52.5	16.6	17.9	34.5	13.0	SL
2	2	AP	0-20	0.1	4.5	13.6	13.7	9.4	40.3	18.5	21.3	39.8	19.9	L L
2	2	A1	20-31	0.6	4.3	11.9	11.8	8.1	36.7	20.2	20.7	40.9	22.6	L
2	2	A3	31-43	0.8	4.2	11.6	10.7	7.4	34.7	19.5	23.3	42.8	22.5	L
2	2	B1	43-58	1.0	4.9	12.1	12.1	8.3	38.4	18.3	21.8	40.1	21.5	L
2	2	B21	58-74	1.3	4.2	11.4	10.8	15.4	43.4	18.1	20.8	38.9	17.7	L L
2	2	B22	74-84	4.4	7.4	15.7	14.6	10.1	53.2	11.4	16.7	28.1	18.7	SL
2	2	B3	84-94	2.4	5.9	16.0	15.9	11.8	51.9	16.6	17.6	34.2	13.9	L L
2	2	C1	94-104	2.3	5.5	13.7	12.3	10.4	44.3	24.9	16.5	41.4	14.3	L L
2	2	C1	104-114	1.9	7.0	14.8	13.6	10.1	47.4	16.1	22.7	38.8	13.8	L L
2	2	C2	114-130	1.5	7.3	14.6	13.5	11.3	48.2	17.1	20.7	37.8	14.0	L L
2	2	C2	130-145	2.1	6.0	13.6	13.8	11.3	46.8	17.8	21.4	39.2	14.0	L L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
2	2	C2	145-160	0.9	5.1	14.5	14.7	11.3	46.5	18.5	21.7	40.2	13.3	L L
2	2	C2	160-175	2.4	7.1	16.1	14.5	8.0	48.1	19.3	19.5	38.8	13.1	L L
2	2	C2	175-191	3.7	7.7	15.0	14.4	8.0	49.1	16.3	21.9	38.2	12.5	L L
2	2	C2	191-203	2.7	7.9	15.6	14.4	8.2	48.8	17.4	21.6	39.0	12.2	L L
2	2	C2	203-214	3.0	7.0	15.5	14.2	8.8	48.5	18.5	19.7	38.2	13.3	L L
2	2	C2	214-229	2.8	6.6	14.8	14.1	9.5	47.8	19.0	19.5	38.5	13.7	L L
2	2	C2	229-244	1.8	8.1	16.2	14.4	8.8	49.3	11.1	21.6	32.7	18.0	L L
2	2	C2	244-254	1.7	6.6	15.7	15.6	8.4	48.0	17.7	21.9	39.6	12.4	L L
2	2	C2	254-264	2.5	6.5	17.9	16.0	8.5	50.4	14.0	20.9	34.9	14.7	L L
2	2	C3	264-279	3.2	8.2	16.4	14.6	10.7	53.1	15.4	13.1	33.5	13.4	SL
2	2	C3	279-292	2.7	7.9	16.3	14.5	11.6	53.0	16.2	17.1	33.3	13.7	SL
2	2	C4	292-305	3.3	6.8	15.4	14.9	11.6	52.0	16.0	18.4	34.4	13.5	L L
2	3	AP	0-20	3.6	7.6	16.3	13.7	7.9	49.1	15.5	15.1	30.6	20.3	L
2	3	A1	20-31	0.8	5.6	15.7	14.4	10.8	47.3	15.3	16.1	31.4	21.3	L
2	3	A3	31-43	1.8	6.1	15.6	14.6	9.4	47.5	15.5	16.2	31.7	20.6	L
2	3	B1	43-53	3.1	6.7	15.3	14.2	10.2	49.5	14.1	16.2	30.3	20.2	L
2	3	B2G	53-61	2.1	6.2	15.1	14.5	10.4	48.3	16.8	15.7	33.5	18.2	L L
2	3	B2G	61-69	3.0	7.1	15.1	15.2	9.2	49.6	15.6	18.0	33.6	16.8	L L
2	3	B3G	69-76	4.3	7.7	14.0	14.0	9.9	50.5	16.6	18.3	34.9	14.6	L L
2	3	B3G	76-86	5.6	8.6	14.5	14.1	11.1	53.9	13.6	17.2	30.8	15.3	SL
2	3	C1G	86-97	5.8	8.6	14.5	14.1	9.0	52.0	17.0	16.7	33.7	14.3	SL
2	3	C1G	97-107	3.9	7.0	15.2	14.3	10.6	51.0	15.9	18.5	50.3	14.6	L L
2	3	C2G	107-122	3.1	6.7	15.1	14.5	11.3	50.7	16.6	18.3	34.9	14.4	L L
2	3	C2G	122-132	2.4	6.7	15.8	14.1	12.7	51.7	16.5	17.9	34.4	13.9	L L
2	3	C2G	132-147	3.0	7.0	18.0	13.9	7.5	49.4	17.5	19.1	36.6	14.0	L L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTALS	CSILT	FSILT	TOTSILT	CLAY	TEXTURE
2	3	C2G	147-163	1.9	6.7	14.8	14.0	13.1	50.5	15.3	19.8	35.1	14.4	L L
2	3	C2G	163-173	3.5	6.7	14.3	14.4	12.6	51.5	15.4	16.9	32.3	16.2	L L
2	3	C2G	173-188	2.5	7.0	14.1	10.3	17.3	51.2	19.4	13.7	33.1	15.7	L L
2	3	C3G	188-198	4.0	7.5	14.1	14.8	11.7	52.1	18.4	16.2	34.6	12.9	LSL
2	3	C4G	198-208	4.0	6.5	14.3	15.0	4.9	44.7	23.2	17.0	40.2	15.1	L L
2	3	C5G	208-218	4.0	7.7	13.8	14.3	12.9	52.7	15.7	17.4	33.1	14.2	SL
2	3	C6G	218-229	2.1	6.7	13.8	14.7	13.8	51.1	16.8	18.2	35.0	13.9	L L
2	3	C7G	229-241	3.7	6.7	14.1	14.8	13.1	52.4	15.1	17.4	32.5	15.1	SL
2	3	C7G	241-262	3.8	7.4	13.9	15.4	14.1	54.6	13.7	18.1	31.8	13.6	SL
2	3	C8G	262-277	1.6	6.0	14.3	15.0	12.0	48.9	16.8	19.9	36.7	14.4	L L
2	3	C9G	277-282	2.4	7.8	14.2	14.5	13.3	52.2	15.6	17.7	33.3	14.5	SL
2	4	AP	0-20	0.9	5.3	13.0	12.5	11.2	42.9	16.8	17.6	34.4	22.7	L
2	4	A1	20-31	0.9	4.5	11.9	12.7	11.1	41.1	18.9	16.6	35.5	23.4	L
2	4	A3	31-41	1.2	5.2	12.0	12.7	10.7	41.8	15.7	19.0	34.7	23.5	L
2	4	B1	41-51	0.7	5.0	11.7	13.3	11.9	42.6	15.5	18.4	33.9	23.5	L
2	4	B2G	51-64	1.7	6.2	12.3	13.2	11.2	44.6	16.9	16.5	33.4	22.0	L
2	4	B3G	64-74	1.3	6.0	11.3	12.3	14.8	45.4	17.3	16.5	33.8	20.8	L
2	4	B3G	74-84	3.4	5.8	13.4	14.1	15.7	52.4	15.0	15.1	30.1	17.4	SL
2	4	C1G	84-99	3.6	6.4	13.7	14.8	14.4	52.9	10.8	17.3	28.1	19.0	SL
2	4	C2G	99-109	3.8	8.5	18.5	22.5	17.6	70.9	6.5	15.3	21.8	7.3	LS
2	4	C3G	109-127	1.7	5.3	19.0	22.8	17.1	65.9	11.9	12.8	24.7	9.4	SL
2	4	C3G	127-140	6.5	1.0	15.4	17.2	10.6	54.2	9.5	15.3	24.8	14.5	SL
2	4	C4G	140-150	7.1	4.3	31.1	21.1	8.3	81.9	6.3	6.1	12.4	6.1	LS
2	4	C5G	150-165	2.1	5.4	13.2	12.6	10.7	44.0	25.7	17.4	[illegible]	12.9	L L
2	4	C5G	165-180	1.8	6.0	14.0	13.9	11.5	47.1	21.1	18.0	34.1	13.8	L L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTALS	CSILT	FSILT	TOTSILT	CLAY	TEXTURE
2	4	C5G	180-196	1.6	6.3	14.6	14.9	13.5	50.9	16.1	18.8	34.9	14.3	L L
2	4	C5G	196-211	2.4	6.4	13.5	14.1	14.4	50.8	16.3	18.0	34.3	14.9	L L
2	4	C6G	211-225	1.8	6.5	14.6	14.2	14.4	51.5	15.1	18.2	33.3	15.2	L L
2	4	C7G	226-242	2.8	5.4	15.0	14.7	14.7	53.6	15.3	17.3	32.6	13.8	SL
2	4	C8G	242-254	7.2	5.9	30.6	17.4	8.8	79.9	6.8	7.1	13.9	6.2	LS
2	4	C9G	254-262	2.4	0.9	14.4	12.4	11.0	61.1	12.2	14.9	27.1	11.8	SL
2	4	C9G	262-274	2.4	8.0	19.4	17.9	13.8	61.5	13.2	15.2	38.4	10.1	SL
2	4	C10	274-290	1.8	6.5	15.4	15.5	14.7	54.9	12.1	19.5	31.6	13.5	SL
2	4	C11	290-305	1.8	6.3	14.9	14.1	13.5	50.6	15.2	19.6	34.8	14.6	L L
2	5	APCA	0-20	0.3	1.6	5.8	6.9	9.2	23.8	16.7	27.7	44.4	31.8	CL
2	5	A1CA	20-33	0.1	2.0	5.5	6.6	10.8	25.0	16.7	27.9	44.6	30.4	L CL
2	5	A3CA	33-43	0.1	1.7	5.6	7.9	8.1	23.4	17.7	26.1	43.8	32.8	CL
2	5	B1GC	43-51	0.2	2.2	5.9	7.1	8.6	24.0	18.8	23.4	42.2	33.8	CL
2	5	B1GC	51-58	0.3	2.3	6.0	7.4	11.0	27.0	18.0	26.1	44.1	28.9	L CL
2	5	B2G	58-69	0.4	2.2	6.1	7.0	8.4	24.1	19.1	28.3	47.4	28.5	L CL
2	5	B2G	69-76	0.4	2.2	5.7	7.4	9.1	24.8	22.8	27.7	50.5	24.7	L
2	5	B3G	76-89	0.4	1.4	5.0	6.4	9.1	22.3	27.3	28.7	56.0	21.7	L
2	5	B3G	89-104	0.8	2.6	7.4	8.6	12.1	31.5	24.9	25.5	50.4	18.1	L L
2	5	C1G	104-119	2.0	6.4	13.0	13.2	13.7	48.3	18.3	19.1	37.4	14.3	L L
2	5	C1G	119-130	2.7	5.5	9.8	12.1	14.9	45.0	21.0	20.2	41.2	13.8	L L
2	5	C1G	130-142	2.7	5.5	9.9	12.0	15.4	45.5	18.6	22.0	40.6	13.9	L L
2	5	C1G	142-152	2.4	4.2	4.9	13.1	27.0	51.6	27.0	11.9	38.9	9.5	L L
2	5	C1G	152-163	0.5	1.1	1.5	6.8	27.6	37.5	38.2	15.3	53.6	9.0	L L
2	5	C1G	163-173	0.3	1.5	2.5	5.9	24.6	34.8	32.8	22.5	55.3	9.9	L L
2	5	C2G	173-185	4.4	8.2	18.8	19.9	15.3	66.6	16.8	9.6	28.4	5.0	SL

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
2	5	C2G	185-196	2.8	7.4	15.5	15.7	12.6	54.0	17.7	15.8	33.6	12.5	SL
2	5	C2G	196-206	3.3	7.8	15.2	14.7	13.6	54.6	16.0	16.4	32.4	13.0	SL
2	5	C3G	206-218	2.8	6.1	27.5	28.3	14.1	78.8	12.6	4.3	16.9	4.3	LS
2	5	C3G	218-236	5.2	1.1	29.4	24.6	13.1	83.4	8.0	6.0	14.0	2.6	LS
2	5	C4G	236-249	4.3	7.9	16.4	15.4	11.5	55.2	16.4	17.1	33.5	11.3	SL
2	5	C5G	249-264	3.3	7.3	14.8	14.6	12.0	52.0	17.3	18.0	35.3	12.7	L L
2	5	C6	264-279	3.5	7.6	15.7	14.7	10.9	52.4	8.9	25.9	34.8	12.8	SL
2	5	C7	279-292	3.1	6.3	14.5	15.1	12.1	51.1	16.9	17.8	34.7	14.2	L L
2	5	C7	292-305	3.2	7.2	15.1	14.4	11.2	51.1	18.5	18.2	36.7	18.5	L L
2	6	AP	0-20	0.4	3.0	6.4	7.1	7.5	24.4	21.7	24.3	46.0	29.6	L CL
2	6	A12	20-31	0.7	2.8	7.8	8.6	9.2	29.1	16.4	25.4	41.8	29.1	L CL
2	6	A13	31-41	1.7	3.0	7.6	9.8	6.4	28.5	19.2	23.1	42.3	29.2	L CL
2	6	A14	41-51	1.3	3.0	8.4	9.2	7.7	29.6	17.6	23.8	41.4	29.0	L CL
2	6	A15	51-56	1.5	3.4	9.5	9.7	8.7	32.8	16.5	22.5	39.0	28.2	L CL
2	6	B1	56-61	0.5	2.6	7.8	8.4	7.0	26.4	17.6	24.6	42.2	31.4	L CL
2	6	B1	61-71	0.7	2.8	6.7	6.7	6.9	23.8	17.8	26.0	43.8	32.4	L CL
2	6	B21G	71-81	1.2	3.5	9.9	9.9	10.2	34.8	15.4	23.5	37.9	27.3	L CL
2	6	B22G	81-91	2.4	6.2	17.1	15.1	11.7	52.5	14.7	15.4	30.1	17.4	SL
2	6	B22G	91-102	2.3	5.5	15.6	15.0	13.7	52.1	13.7	16.3	30.0	17.9	SL
2	6	B3G	102-112	2.8	6.1	14.8	13.5	11.8	49.0	14.2	18.6	32.8	18.2	L L
2	6	B3G	112-122	2.3	5.7	13.4	12.1	11.9	45.4	14.3	21.7	36.0	18.6	L L
2	6	B3G	122-132	2.2	5.3	11.8	11.6	12.3	43.2	15.4	22.6	38.0	18.8	L L
2	6	C1G	132-142	2.7	7.1	15.4	12.4	13.3	50.9	15.5	19.1	34.6	14.5	L L
2	6	C1G	142-152	3.7	5.7	12.9	12.7	12.9	47.9	16.7	20.1	36.8	15.3	L L
2	6	C1G	152-163	3.9	5.1	14.1	12.7	12.2	49.0	15.2	21.1	36.3	14.7	L L

TRV	SS	HORIZON	DEPTH	VCS	CS	MS	FS	VFS	TOTAL S	C SILT	F SILT	TOT SILT	CLAY	TEXTURE
2	6	C20	163-173	2.9	6.2	15.6	14.8	13.0	52.0	15.5	18.7	34.2	13.3	SL
2	6	C30	173-183	2.5	7.3	15.1	13.1	13.5	51.5	15.6	18.9	34.5	14.0	L L
2	6	C40	183-193	3.0	6.5	13.4	13.2	15.8	52.5	12.5	20.3	32.8	14.7	SL
2	6	C40	193-203	3.9	7.0	15.8	13.5	12.5	53.1	14.0	19.0	33.0	13.0	SL
2	6	C50	203-213	3.3	6.2	15.1	13.9	12.8	51.3	15.4	19.6	35.0	13.7	L L
2	6	C50	213-234	3.2	6.4	15.2	13.8	12.8	51.4	15.4	19.5	34.9	13.7	L L
2	6	C50	234-244	3.4	6.3	15.4	13.9	12.3	51.3	16.4	18.7	35.1	13.6	L L
2	6	C50	244-254	3.2	6.1	15.0	13.8	13.0	51.1	16.3	18.8	35.1	13.8	L L
2	6	C6	254-269	3.1	6.4	15.3	13.7	12.5	51.0	18.2	17.9	36.1	12.9	L L

APPENDIX D: CHEMICAL DATA

Glossary of Terms

TRV	traverse number. artificially drained Clarion toposequence = 1, undrained Clarion toposequence = 2.
SS	soil series site within traverse. Clarion = 1, Nicollet = 2, Webster = 3, Canisteo = 4, Harps = 5, Okoboji = 6.
HORIZON	horizon identification.
DEPTH	depth of horizon (cm).
pH	pH of horizon sampled.
TP	total phosphorus (ppm).
OP	organic phosphorus (ppm).
IC	inorganic phosphorus (ppm).
OC	organic carbon (%).
FREEFE	free iron (%).
FE203	ferric oxide (%).
OCOPRTO	organic carbon organic phosphorus ratio.
OPTPRTO	organic phosphorus total phosphorus ratio.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTO
1	1	AP	0-20	6.0	410	261	149	2.0	1.1	1.6	76	64
1	1	A3	20-31	6.0	313	209	104	1.6	1.4	2.3	76	67
1	1	B1	31-41	6.1	284	192	92	1.0	1.0	1.4	52	68
1	1	B21	41-56	6.1	258	159	99	0.7	1.2	1.7	44	62
1	1	B22	56-69	6.2	244	129	115	0.4	0.8	1.1	31	53
1	1	B3	69-79	7.3	333	40	293	0.2	0.7	1.0	50	12
1	1	C1	79-92	7.6	323	.	.	.	0.7	1.0	.	.
1	1	C1	92-107	7.6	304	.	.	.	0.7	1.0	.	.
1	1	C2	107-122	7.8	344	6	338	0.2	0.6	0.9	.	2
1	1	C2	122-137	7.8	.	.	.	.	.	.	.	.
1	1	C3	137-152	7.8	319	6	313	0.2	0.7	1.0	.	2
1	1	C3	152-168	7.8	.	.	.	.	.	.	.	.
1	1	C3	168-183	7.8	334	.	.	.	0.7	1.0	.	.
1	1	C4	183-198	7.8	.	.	.	.	.	.	.	.
1	1	C5	198-213	7.8	343	.	.	.	0.8	1.1	.	.
1	1	C5	213-229	7.8	.	.	.	.	.	.	.	.
1	1	C5	229-244	7.8	368	.	.	.	0.6	0.9	.	.
1	1	C5	244-259	7.8	.	.	.	.	.	.	.	.
1	1	C5	259-274	7.9	323	.	.	.	0.6	0.9	.	.
1	1	C5	274-295	7.9	303	.	.	.	0.7	1.0	.	.
1	2	AP	0-20	6.5	466	295	171	2.4	0.7	1.0	81	63
1	2	A12	20-30	6.2	457	289	168	2.2	0.8	1.1	76	63
1	2	A3	30-51	6.1	428	286	142	1.9	1.0	1.4	66	66
1	2	B1	51-61	6.1	360	253	107	2.0	0.9	1.3	79	70
1	2	B21	61-79	6.1	298	191	107	1.5	0.9	1.3	79	64
1	2	B22	79-89	6.2	281	245	36	1.0	0.8	1.1	41	87
1	2	B3	89-107	6.8	291	253	38	0.9	0.8	1.1	36	86
1	2	C1	107-122	7.4	261	37	224	0.3	0.8	1.1	81	14
1	2	C2	122-132	7.6	.	.	.	.	.	.	.	.
1	2	C2	132-142	7.8	233	5	228	0.2	0.5	0.7	0	2
1	2	C3	142-158	7.8	.	.	.	.	.	.	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTO
1	2	C3	158-173	7.8	350	.	.	.	0.7	1.0	.	.
1	2	C4	173-188	7.8	.	.	.	.	.	.	.	.
1	2	C4	188-203	7.9	450	.	.	.	0.7	1.0	.	.
1	2	C5	203-211	8.0	.	.	.	.	.	.	.	.
1	2	C6	211-226	8.0	325	.	.	.	0.7	1.0	.	.
1	2	C7	222-241	8.0	.	.	.	.	.	.	.	.
1	2	C8	241-252	8.0	388	.	.	.	0.7	1.0	.	.
1	2	C9	252-264	8.0	.	.	.	.	1.0	1.4	.	.
1	2	C9	264-274	8.0	399	.	.	.	1.0	1.4	.	.
1	3	AP	0-20	6.7	560	429	131	3.1	0.6	0.9	72	76
1	3	A12	20-31	6.7	541	414	127	2.6	0.5	0.7	62	76
1	3	A3	31-41	6.9	365	276	89	1.2	0.3	0.4	43	75
1	3	B1	41-51	7.3	482	263	85	1.0	0.4	0.6	38	75
1	3	B21G	51-66	7.0	335	186	149	0.7	0.4	0.6	37	55
1	3	B22G	66-76	7.1	321	188	133	0.5	0.3	0.4	27	58
1	3	B31G	76-91	7.4	334	.	.	.	0.4	0.6	.	.
1	3	B32G	91-99	7.6	369	210	158	0.3	0.5	0.7	14	57
1	3	C1G	99-112	7.6	334	178	156	0.2	0.8	1.1	11	53
1	3	C2G	112-125	7.7	366	.	.	.	0.9	1.3	.	.
1	3	C2G	125-140	7.7	.	.	.	.	.	.	.	.
1	3	C3G	140-155	7.9	210	.	.	.	0.5	0.7	.	.
1	3	C4G	155-168	7.9	.	.	.	.	.	.	.	.
1	3	C4G	168-183	7.6	288	9	279	0.1	0.5	0.7	11	31
1	3	C4G	183-198	7.6	.	.	.	.	.	.	.	.
1	3	C5G	198-213	7.9	311	.	.	.	0.9	1.3	.	.
1	3	C5G	213-229	7.8	.	.	.	.	.	.	.	.
1	3	C6G	229-244	7.7	381	.	.	.	0.8	1.1	.	.
1	3	C6G	244-259	7.9	.	.	.	.	.	.	.	.
1	3	C6G	259-274	7.8	350	.	.	.	0.8	1.1	.	.
1	3	C7G	274-290	7.8	.	.	.	.	.	.	.	.
1	3	C7G	290-310	7.8	374	.	.	.	0.6	0.9	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTO
1	3	C7G	310-325	7.5	.	.	.	.	.	.	.	.
1	3	C7G	325-338	7.6	342	.	.	.	0.3	0.4	.	.
1	4	AP	0-20	7.5	688	394	294	4.3	0.4	0.6	9	57
1	4	A1	20-33	7.6	658	377	281	3.4	0.3	0.4	90	57
1	4	A3	33-43	7.4	572	423	149	2.3	0.3	0.4	54	35
1	4	B1	43-56	7.4	405	300	105	1.7	0.4	0.6	57	74
1	4	B21G	56-69	7.4	326	168	158	1.1	0.3	0.4	65	51
1	4	B22G	69-76	7.4	287	163	124	0.9	0.4	0.6	55	56
1	4	B23G	76-89	7.4	298	.	.	.	0.4	0.6	.	.
1	4	B24G	89-97	7.4	291	157	134	0.6	0.4	0.6	38	53
1	4	B31G	97-109	7.4	379	204	175	0.6	0.5	0.7	29	53
1	4	B32G	109-117	7.3	431	.	.	.	0.7	1.0	.	.
1	4	B32G	117-127	7.3	548	.	.	.	0.2	0.3	.	.
1	4	C1G	127-137	7.3	521	192	329	0.5	.	.	26	36
1	4	C2G	137-147	7.2	519	.	.	.	0.6	0.9	.	.
1	4	C2G	147-163	7.3	611	156	455	0.2	.	.	13	25
1	4	C3G	163-173	7.3	632	.	.	.	0.8	1.1	.	.
1	4	C3G	173-183	7.3	.	.	.	.	.	.	.	.
1	4	C3G	183-198	7.3	666	.	.	.	0.9	1.3	.	.
1	4	C3G	198-214	7.5	.	.	.	.	.	.	.	.
1	4	C4G	214-229	7.7	531	.	.	.	0.6	0.9	.	.
1	4	C4G	229-236	7.8	.	.	.	.	.	.	.	.
1	4	C4G	236-252	7.8	517	.	.	.	0.7	1.0	.	.
1	4	C4G	252-267	7.8	.	.	.	.	.	.	.	.
1	4	C4G	267-282	7.8	458	.	.	.	0.8	1.1	.	.
1	4	C4G	282-305	7.8	371	.	.	.	0.2	0.3	.	.
1	5	APCA	0-20	7.7	695	428	267	5.0	0.4	0.6	17	61
1	5	A1CA	20-36	7.8	618	381	237	4.3	0.3	0.4	70	61
1	5	A3CA	36-46	7.8	486	170	316	1.4	0.3	0.4	29	35
1	5	B1GC	46-56	7.8	386	118	268	1.1	0.3	0.4	28	30
1	5	B21G	56-66	7.8	397	78	319	0.9	0.3	0.4	15	19

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	CPTPRTO
1	5	B21G	66-76	7.8	436	64	372	0.8	0.4	0.6	25	14
1	5	B22G	76-86	7.9	406	52	354	0.7	0.3	0.4	35	12
1	5	B3G	86-94	8.0	389	.	.	.	0.4	0.6	.	.
1	5	B3G	94-102	7.8	470	.	.	.	0.6	0.9	.	.
1	5	C1G	102-112	7.8	409	.	.	.	0.9	1.3	.	.
1	5	C1G	112-122	7.8	310	.	.	.	0.5	0.7	.	.
1	5	C2G	122-137	7.8	321	22	299	0.2	.	.	90	6
1	5	C2G	137-145	7.7	405	.	.	.	0.4	0.6	.	.
1	5	C3G	145-160	7.8	.	.	.	.	.	.	.	.
1	5	C4G	160-173	7.8	379	.	.	.	1.0	1.4	.	.
1	5	C5G	173-188	7.8	.	.	.	.	.	.	.	.
1	5	C5G	188-203	7.8	799	.	.	.	0.5	0.7	.	.
1	5	C5G	203-219	7.9	.	.	.	.	.	.	.	.
1	5	C6G	219-234	7.9	519	.	.	.	0.8	1.1	.	.
1	5	C7G	234-249	7.9	.	.	.	.	.	.	.	.
1	5	C7G	249-257	8.0	349	.	.	.	0.7	1.0	.	.
1	5	C8G	257-272	7.9	.	.	.	.	.	.	.	.
1	5	C9G	272-287	7.9	.	.	.	.	0.7	1.0	.	.
1	5	C9G	287-300	8.0	400	.	.	.	0.8	1.1	.	.
1	5	C9G	300-307	8.0	.	.	.	.	.	.	.	.
1	5	C9G	307-323	8.0	384	.	.	.	0.9	1.3	.	.
1	5	C9G	323-333	7.9	372	.	.	.	1.0	1.4	.	.
1	6	AP	0-20	7.2	942	480	462	5.7	0.8	1.1	60	51
1	6	A12	20-28	7.3	820	542	278	5.5	0.6	0.9	67	66
1	6	A13	28-36	7.3	810	630	180	5.3	0.5	0.7	65	77
1	6	A14	36-43	7.2	704	548	156	5.1	0.4	0.6	72	77
1	6	A15	43-51	7.2	552	139	413	4.7	0.4	0.6	85	25
1	6	A3	51-64	7.3	490	124	366	4.2	0.5	0.7	86	25
1	6	B1G	64-74	7.4	500	92	408	1.8	0.5	0.7	36	18
1	6	B21G	74-82	7.4	463	79	384	1.3	0.6	0.9	28	17
1	6	B22G	82-89	7.4	467	67	400	0.6	0.6	0.9	13	14

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	CPTPRTO
1	6	B23G	89-99	7.5	377	.	.	.	0.7	1.0	.	.
1	6	B31G	99-109	7.6	423	.	.	.	0.6	0.9	.	.
1	6	B32G	109-122	7.7	451	.	.	.	0.4	0.6	.	.
1	6	B32G	122-135	7.8	.	.	.	.	.	.	.	.
1	6	C1G	135-147	7.8	435	7	428	0.1	0.3	0.4	42	.
1	6	C1G	147-160	7.8	.	.	.	.	.	.	.	.
1	6	C2G	160-173	7.9	473	.	.	.	0.8	1.1	.	.
1	6	C2G	173-183	7.9	.	.	.	.	.	.	.	.
1	6	C3G	183-198	7.9	457	.	.	.	0.7	1.0	.	.
1	6	C3G	198-214	7.9	.	.	.	.	.	.	.	.
1	6	C3G	214-224	7.9	402	.	.	.	0.6	0.9	.	.
1	6	C3G	224-234	7.9	.	.	.	.	.	.	.	.
1	6	C4G	234-249	8.0	419	.	.	.	0.7	1.0	.	.
1	6	C4G	249-264	8.0	.	.	.	.	.	.	.	.
1	6	C4G	264-279	7.9	386	.	.	.	0.8	1.1	.	.
1	6	C5G	279-292	7.8	.	.	.	.	.	.	.	.
1	6	C5G	292-305	7.7	384	.	.	.	0.6	.	.	.
2	1	AP	0-20	5.1	366	232	134	1.9	0.8	1.1	82	53
2	1	A1	20-31	5.2	365	246	119	1.7	1.0	1.4	69	67
2	1	A3	31-43	5.2	278	189	89	1.0	1.0	1.4	36	68
2	1	B1	43-58	5.3	270	171	99	0.7	1.0	1.4	26	63
2	1	B21	58-71	5.4	222	118	104	0.4	1.0	1.4	34	53
2	1	B21	71-82	5.5	202	27	175	0.2	1.0	1.4	74	13
2	1	B22	82-94	5.9	237	.	.	.	0.8	1.1	.	.
2	1	B3	94-104	6.8	280	6	274	0.2	0.8	1.1	33	2
2	1	C1	104-117	7.3	422	.	.	.	0.8	1.1	.	.
2	1	C1	117-122	7.5	381	4	377	0.1	.	.	50	1
2	1	C2	122-138	7.6	.	.	.	.	0.7	1.0	.	.
2	1	C2	138-152	7.6	347	3	344	0.1	.	.	33	1
2	1	C2	152-177	7.6	.	.	.	.	1.1	1.6	.	.
2	1	C3	177-183	7.7	347	.	.	.	.	.	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	CPTPRTO
2	1	C3	183-198	7.7	.	.	.	.	0.7	1.0	.	.
2	1	C4	198-213	7.7	322	.	.	.	.	.	.	.
2	1	C4	213-229	7.7	.	.	.	.	0.7	1.0	.	.
2	1	C5	229-244	7.7	381	.	.	.	.	.	.	.
2	1	C5	244-254	7.8	.	.	.	.	0.8	1.1	.	.
2	1	C5	254-269	7.8	381	.	.	.	.	.	.	.
2	1	C5	269-285	7.8	.	.	.	.	0.8	1.1	.	.
2	1	C5	285-300	7.8	390	.	.	.	.	.	.	.
2	1	C5	300-305	7.8	350	.	.	.	0.7	1.0	.	.
2	2	AP	0-20	5.4	367	237	130	2.5	0.9	1.3	5	64
2	2	A1	20-31	5.6	381	241	140	2.3	0.9	1.3	95	63
2	2	A3	31-43	5.7	313	212	101	2.0	0.9	1.3	94	67
2	2	B1	43-58	5.8	251	180	71	1.9	1.0	1.4	56	71
2	2	B21	58-74	6.1	226	136	90	1.6	1.1	1.6	18	60
2	2	B22	74-84	6.5	238	108	130	1.1	1.0	1.4	1	45
2	2	B3	84-94	6.6	398	110	288	0.7	0.7	1.0	63	27
2	2	C1	94-104	6.9	332	34	298	0.3	0.6	0.9	88	10
2	2	C1	104-114	7.3	361	.	.	.	0.7	1.0	.	.
2	2	C2	114-130	7.7	301	7	294	0.1	0.7	1.0	43	2
2	2	C2	130-145	7.9	.	.	.	.	.	.	.	.
2	2	C2	145-160	7.9	291	6	285	0.1	0.7	1.0	67	2
2	2	C2	160-175	8.0	.	.	.	.	0.7	1.0	.	.
2	2	C2	175-191	7.8	327	.	.	.	0.7	1.0	.	.
2	2	C2	191-203	7.7	.	.	.	.	.	.	.	.
2	2	C2	203-214	8.0	345	.	.	.	0.7	1.0	.	.
2	2	C2	214-229	7.9	.	.	.	.	.	.	.	.
2	2	C2	229-244	7.8	367	.	.	.	0.7	1.0	.	.
2	2	C2	244-254	8.0	.	.	.	.	.	.	.	.
2	2	C2	254-264	8.0	344	.	.	.	0.6	0.9	.	.
2	2	C3	264-279	8.1	.	.	.	.	.	.	.	.
2	2	C3	279-292	8.0	327	.	.	.	0.6	0.9	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTO
2	2	C4	292-305	8.0	356	.	.	.	0.8	1.1	.	.
2	3	AP	0-20	6.7	435	340	95	3.7	0.8	1.1	9	78
2	3	A1	20-31	6.7	430	320	110	3.0	0.6	0.9	93	74
2	3	A3	31-43	7.0	375	280	95	2.6	0.6	0.9	92	74
2	3	B1	43-53	7.3	317	240	77	1.2	0.8	1.1	50	75
2	3	B2G	53-61	7.4	297	210	87	1.0	0.9	1.3	48	70
2	3	B2G	61-69	7.5	300	212	88	0.8	0.8	1.1	38	70
2	3	B3G	69-76	7.6	328	218	110	0.5	0.6	0.9	23	66
2	3	B3G	76-86	7.7	333	190	143	0.4	0.6	0.9	21	57
2	3	C1G	86-97	7.8	320	160	160	0.3	0.7	1.0	18	50
2	3	C1G	97-107	7.7	332	.	.	.	0.7	1.0	.	.
2	3	C2G	107-122	7.7	345	70	275	0.2	0.6	0.9	28	20
2	3	C2G	122-132	7.8	.	.	.	.	.	.	.	.
2	3	C2G	132-147	7.7	334	.	.	.	0.9	0.9	.	.
2	3	C2G	147-163	7.8	.	.	.	.	.	.	.	.
2	3	C2G	163-173	7.7	364	7	357	0.1	0.8	1.1	43	2
2	3	C2G	173-188	7.7	.	.	.	.	.	.	.	.
2	3	C3G	188-198	7.8	313	.	.	.	0.7	1.0	.	.
2	3	C4G	198-208	7.8	.	.	.	.	.	.	.	.
2	3	C5G	208-218	7.8	324	.	.	.	0.7	1.0	.	.
2	3	C6G	218-229	7.8	.	.	.	.	.	.	.	.
2	3	C7G	229-241	7.8	263	.	.	.	0.6	0.9	.	.
2	3	C7G	241-262	7.8	.	.	.	.	.	.	.	.
2	3	C8G	262-277	7.9	346	.	.	.	0.5	0.7	.	.
2	3	C9G	277-282	7.6	401	.	.	.	0.6	0.9	.	.
2	4	AP	0-20	7.4	498	290	208	4.7	0.4	0.6	62	58
2	4	A1	20-31	7.4	488	271	217	3.6	0.4	0.6	33	55
2	4	A3	31-41	7.5	349	310	39	2.4	0.1	.	77	88
2	4	B1	41-51	7.6	330	240	90	1.8	0.4	0.6	75	72
2	4	B2G	51-64	7.6	303	178	125	1.2	0.4	0.6	59	58
2	4	B3G	64-74	7.5	339	100	239	0.8	0.5	0.7	80	29

TRV	SS	HORIZCN	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTC
2	4	B3G	74-84	7.6	318	110	209	0.5	0.4	0.6	45	34
2	4	C1G	84-99	7.8	321	.	.	.	0.3	0.4	.	.
2	4	C2G	99-109	7.7	284	.	.	.	0.4	0.6	.	.
2	4	C3G	109-127	7.6	296	40	256	0.2	0.4	0.6	50	13
2	4	C3G	127-140	7.7	225	.	.	0.1	0.1	.	.	.
2	4	C4G	140-150	7.8	.	.	.	.	.	.	.	.
2	4	C5G	150-165	7.8	.	.	.	.	0.7	1.0	.	.
2	4	C5G	165-180	7.8	350	.	.	.	.	.	.	.
2	4	C5G	180-196	7.7	.	.	.	.	0.8	1.1	.	.
2	4	C5G	196-211	7.7	333	.	.	.	.	.	.	.
2	4	C6G	211-226	7.7	.	.	.	.	0.7	1.0	.	.
2	4	C7G	226-242	7.8	358	.	.	.	.	.	.	.
2	4	C8G	242-254	7.7	.	.	.	.	0.4	0.6	.	.
2	4	C98	254-262	7.8	295	.	.	.	.	.	.	.
2	4	C98	262-274	7.7	.	.	.	.	0.4	0.6	.	.
2	4	C10	274-290	7.7	343	.	.	.	.	.	.	.
2	4	C11	290-305	7.7	410	.	.	.	1.0	1.4	.	.
2	5	APCA	0-20	7.7	725	470	255	5.2	0.2	0.3	11	64
2	5	A1CA	20-33	7.7	666	410	256	4.6	0.1	0.1	12	61
2	5	A3CA	33-43	7.7	539	220	319	2.0	0.1	0.1	90	40
2	5	B1GC	43-51	7.7	476	180	296	2.7	0.1	0.1	50	37
2	5	B1GC	51-58	7.6	435	110	325	0.9	0.1	0.1	92	25
2	5	B2G	58-69	7.6	445	70	375	0.8	0.1	0.1	14	15
2	5	B2G	69-76	7.7	396	60	336	0.7	0.2	0.3	17	15
2	5	B3G	76-89	7.7	456	68	389	0.6	0.3	0.3	88	14
2	5	B3G	89-104	7.7	404	40	364	0.5	0.1	0.1	25	9
2	5	C1G	104-119	7.7	404	.	.	0.4	0.4	0.6	.	.
2	5	C1G	119-130	7.6	389	12	377	0.2	0.1	0.1	66	3
2	5	C1G	130-142	7.7	.	.	.	.	.	.	.	.
2	5	C1G	142-152	7.7	323	.	.	.	0.4	0.6	.	.
2	5	C1G	152-163	7.7	.	.	.	.	.	.	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	CPIPRTC
2	5	C1G	163-173	7.7	422	.	.	.	0.2	0.3	.	.
2	5	C2G	173-185	7.8	.	.	.	.	.	.	.	.
2	5	C2G	185-196	7.7	317	.	.	.	0.1	0.1	.	.
2	5	C2G	196-206	7.7	.	.	.	.	.	.	.	.
2	5	C3G	206-218	7.7	287	.	.	.	0.2	0.3	.	.
2	5	C3G	218-236	7.7	.	.	.	.	.	.	.	.
2	5	C4G	236-249	7.8	274	.	.	.	0.7	1.0	.	.
2	5	C5G	249-264	7.8	.	.	.	.	.	.	.	.
2	5	C5	264-279	7.7	310	.	.	.	0.5	0.7	.	.
2	5	C7	279-292	7.7	.	.	.	.	.	.	.	.
2	5	C7G	292-305	7.7	362	.	.	.	1.0	1.4	.	.
2	6	AP	0-20	6.3	604	314	290	6.0	0.3	0.4	91	52
2	6	A12	20-31	6.3	527	341	186	5.8	0.3	0.4	70	64
2	6	A13	31-41	6.5	449	352	97	5.2	0.2	0.3	48	78
2	6	A14	41-51	6.8	363	334	49	4.1	0.3	0.4	23	87
2	6	A15	51-56	6.8	323	210	113	3.5	0.3	0.4	67	65
2	6	B1	56-61	6.8	346	187	159	2.0	0.4	0.6	7	54
2	6	B1	61-71	6.9	367	98	269	1.7	0.5	0.7	51	26
2	6	B21G	71-81	7.4	425	.	.	1.0	0.4	0.6	.	.
2	6	B22G	81-91	8.3	425	74	351	0.8	0.2	0.3	8	17
2	6	B22G	91-102	8.1	388	.	.	0.6	0.3	0.4	.	.
2	6	B3G	102-112	7.7	466	61	405	0.6	0.5	0.7	98	13
2	6	B3G	112-122	7.6	549	.	.	0.5	1.3	1.9	.	.
2	6	B3G	122-132	7.9	.	.	.	0.4	.	.	.	.
2	6	C1G	132-142	7.7	437	6	431	0.3	0.7	1.0	50	1
2	6	C1G	142-152	7.7	.	.	.	.	.	.	.	.
2	6	C1G	152-163	7.8	411	.	.	.	0.8	1.1	.	.
2	6	C2G	163-173	7.8	.	.	.	.	.	.	.	.
2	6	C3G	173-183	7.8	328	.	.	.	0.6	0.9	.	.
2	6	C4G	183-193	7.8	.	.	.	.	.	.	.	.
2	6	C4G	193-203	7.9	338	.	.	.	0.5	0.7	.	.

TRV	SS	HORIZON	DEPTH	PH	TP	OP	IP	OC	FREEFE	FE2O3	OCOPRTO	OPTPRTO
2	6	C5G	203-213	7.9	.	.	.	.	.	.	.	.
2	6	C5G	213-234	7.9	315	.	.	.	0.5	0.7	.	.
2	6	C5G	234-244	7.9	.	.	.	.	.	.	.	.
2	6	C5G	244-254	8.0	420	.	.	.	0.4	0.6	.	.
2	6	C5G	254-269	8.0	440	.	.	0.2	.	.	.	.

APPENDIX E: ELECTRODE POTENTIAL DATA

Glossary of Terms

TRV	traverse number. artificially drained Clarion toposequence = 1, undrained Clarion toposequence = 2.
SS	soil series site within traverse. Clarion = 1, Nicollet = 2, Webster = 3, Canisteo = 4, Harps = 5, Okoboji = 6.
MONTH	month of electrode potential measurement.
DAY	day within month of electrode potential measurement.
YEAR	year of electrode potential measurement
DAYYEAR	day within year of electrode potential measurement where January 1 = 1 and December 31 = 365.
ELNO	electrode number.
TIMEMIN	time of electrode potential measurement in minutes.
ECAL	electrode potential measurement (mV) using calomel reference.
AVECAL	average electrode potential measurement (mV) of ECAL
DEHABL	depth of electrode potential measurement above a base line (m)
DWTABL	depth of water table above base line (m).
TEMP	temperature of soil at depth of electrode potential measurement (degrees C).
pH	pH at depth of electrode potential measurement (m).
EH	electrode potential measurements (mV) adjusted to hydrogen reference electrode. these values have been adjusted to pH and temperature.

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
1	1	6	13	79	164	1	5	+323	+293	5.5	4.4	21	6.0	+482
1	1	6	13	79	164	1	6	+323		5.5	4.4	21	6.0	
1	1	6	13	79	164	2	5	+270		5.5	4.4	21	6.0	
1	1	6	13	79	164	2	6	+262		5.5	4.4	21	6.0	
1	1	6	13	79	164	3	5	+299		5.5	4.4	21	6.0	
1	1	6	13	79	164	3	6	+295		5.5	4.4	21	6.0	
1	1	6	13	79	164	1	5	+243	+247	5.2	4.4	19	6.6	+466
1	1	6	13	79	164	1	6	+242		5.2	4.4	19	6.6	
1	1	6	13	79	164	2	5	+252		5.2	4.4	19	6.6	
1	1	6	13	79	164	2	6	+251		5.2	4.4	19	6.6	
1	1	6	13	79	164	1	5	+258	+251	4.9	4.4	17	7.7	+537
1	1	6	13	79	164	1	6	+256		4.9	4.4	17	7.7	
1	1	6	13	79	164	2	5	+244		4.9	4.4	17	7.7	
1	1	6	13	79	164	2	6	+245		4.9	4.4	17	7.7	
1	1	6	13	79	164	1	5	+242	+231	4.6	4.4	15	7.8	+530
1	1	6	13	79	164	1	6	+243		4.6	4.4	15	7.8	
1	1	6	13	79	164	2	5	+219		4.6	4.4	15	7.8	
1	1	6	13	79	164	2	6	+218		4.6	4.4	15	7.8	
1	1	6	13	79	164	1	5	+234	+236	4.3	4.4	14	7.8	+530
1	1	6	13	79	164	1	6	+234		4.3	4.4	14	7.8	
1	1	6	13	79	164	2	5	+235		4.3	4.4	14	7.8	
1	1	6	13	79	164	2	6	+237		4.3	4.4	14	7.8	
1	1	7	25	79	206	1	5	+320	+337	5.5	4.1	26	6.0	+522
1	1	7	25	79	206	1	6	+321		5.5	4.1	26	6.0	
1	1	7	25	79	206	2	5	+319		5.5	4.1	26	6.0	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D•TABL	TEMP	PH	EH
1	1	7	25	79	206	2	6	+318		5.5	4.1	26	6.0	
1	1	7	25	79	206	3	5	+372		5.5	4.1	26	6.0	
1	1	7	25	79	206	3	6	+371		5.5	4.1	26	6.0	
1	1	7	25	79	206	1	5	+297	+291	5.2	4.1	24	6.6	+513
1	1	7	25	79	206	2	5	+284		5.2	4.1	24	6.6	
1	1	7	25	79	206	3	5	+271		5.2	4.1	24	6.6	
1	1	7	25	79	206	1	5	+266	+272	4.9	4.1	21	7.7	+558
1	1	7	25	79	206	1	6	+267		4.9	4.1	21	7.7	
1	1	7	25	79	206	2	5	+246		4.9	4.1	21	7.7	
1	1	7	25	79	206	2	6	+239		4.9	4.1	21	7.7	
1	1	7	25	79	206	3	5	+275		4.9	4.1	21	7.7	
1	1	7	25	79	206	3	6	+276		4.9	4.1	21	7.7	
1	1	7	25	79	206	1	5	+237	+243	4.6	4.1	17	7.6	+540
1	1	7	25	79	206	2	5	+248		4.6	4.1	17	7.8	
1	1	7	25	79	206	3	5	+231		4.6	4.1	17	7.8	
1	1	7	25	79	206	1	7	+220	+219	4.3	4.1	17	7.8	+511
1	1	7	25	79	206	1	8	+219		4.3	4.1	17	7.8	
1	1	7	25	79	206	2	7	+144		4.3	4.1	17	7.8	
1	1	7	25	79	206	2	8	+145		4.3	4.1	17	7.8	
1	1	7	25	79	206	3	7	+219		4.3	4.1	17	7.8	
1	1	7	25	79	206	3	8	+218		4.3	4.1	17	7.8	
1	1	12	15	79	349	1	5	+236	+239	5.5	3.5	0	6.0	+444
1	1	12	15	79	349	2	5	+241		5.5	3.5	0	6.0	
1	1	12	15	79	349	1	5	+273	+279	5.2	3.5	1	6.6	+506
1	1	12	15	79	349	2	5	+282		5.2	3.5	1	6.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	1	12	15	79	349	1	5	+253	+259	4.9	3.5	2	7.7	+562
1	1	12	15	79	349	2	5	+264		4.9	3.5	2	7.7	
1	1	12	15	79	349	1	5	+251	+251	4.6	3.5	5	7.8	+558
1	1	12	15	79	349	2	5	+250		4.6	3.5	5	7.8	
1	1	12	15	79	349	1	5	+214	+218	4.3	3.5	6	7.8	+513
1	1	12	15	79	349	2	5	+221		4.3	3.5	6	7.8	
1	1	5	4	80	124	1	5	+289	+288	5.5	2.6	8	6.0	+486
1	1	5	4	80	124	2	5	+287		5.5	2.6	8	6.0	
1	1	5	4	80	124	3	5	+294		5.5	2.6	8	6.0	
1	1	5	4	80	124	1	5	+361	+373	5.2	2.6	6	6.6	+608
1	1	5	4	80	124	2	5	+371		5.2	2.6	6	6.6	
1	1	5	4	80	124	3	5	+374		5.2	2.6	6	6.6	
1	1	5	4	80	124	1	5	+145	+208	4.9	2.6	6	7.7	+508
1	1	5	4	80	124	2	5	+182		4.9	2.6	6	7.7	
1	1	5	4	80	124	3	5	+213		4.9	2.6	6	7.7	
1	1	5	4	80	124	1	5	+243	+244	4.6	2.6	7	7.8	+549
1	1	5	4	80	124	2	5	+248		4.6	2.6	7	7.8	
1	1	5	4	80	124	3	5	+241		4.6	2.6	7	7.8	
1	1	5	4	80	124	1	5	+214	+227	4.3	2.6	7	7.8	+532
1	1	5	4	80	124	2	5	+239		4.3	2.6	7	7.8	
1	1	5	4	80	124	3	5	+054		4.3	2.6	7	7.8	
1	2	6	13	79	164	1	5	+278	+257	4.3	3.1	21	6.2	+457
1	2	6	13	79	164	1	6	+277		4.3	3.1	21	6.2	
1	2	6	13	79	164	2	5	+238		4.3	3.1	21	6.2	
1	2	6	13	79	164	2	6	+237		4.3	3.1	21	6.2	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	2	6	13	79	164	1	5	+265	+263	4.0	3.1	19	6.1	+458
1	2	6	13	79	164	1	6	+264		4.0	3.1	19	6.1	
1	2	6	13	79	164	2	5	+259		4.0	3.1	19	6.1	
1	2	6	13	79	164	2	6	+262		4.0	3.1	19	6.1	
1	2	6	13	79	164	1	5	+244	+256	3.7	3.1	18	6.2	+458
1	2	6	13	79	164	1	6	+245		3.7	3.1	18	6.2	
1	2	6	13	79	164	2	5	+269		3.7	3.1	18	6.2	
1	2	6	13	79	164	2	6	+267		3.7	3.1	18	6.2	
1	2	6	13	79	164	1	5	+263	+270	3.4	3.1	15	7.4	+545
1	2	6	13	79	164	1	6	+262		3.4	3.1	16	7.4	
1	2	6	13	79	164	2	5	+271		3.4	3.1	16	7.4	
1	2	6	13	79	164	2	6	+278		3.4	3.1	15	7.4	
1	2	6	13	79	164	1	5	+130	+180	3.1	3.1	15	7.6	+444
1	2	6	13	79	164	1	6	+136		3.1	3.1	15	7.8	
1	2	6	13	79	164	2	5	+219		3.1	3.1	15	7.6	
1	2	6	13	79	164	2	6	+224		3.1	3.1	15	7.8	
1	2	6	13	79	164	3	5	-500		3.1	3.1	15	7.8	
1	2	6	13	79	164	3	6	-450		3.1	3.1	15	7.6	
1	2	6	13	79	164	3	7	-405		3.1	3.1	15	7.8	
1	2	6	13	79	164	3	8	-370		3.1	3.1	15	7.8	
1	2	6	13	79	164	3	9	-322		3.1	3.1	15	7.8	
1	2	7	25	79	206	1	5	+324	+364	4.3	3.0	26	6.2	+561
1	2	7	25	79	206	1	6	+324		4.3	3.0	26	6.2	
1	2	7	25	79	206	2	5	+359		4.3	3.0	26	6.2	
1	2	7	25	79	206	2	6	+359		4.3	3.0	26	6.2	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
1	2	7	25	79	206	3	5	+365		4.3	3.0	26	6.2	
1	2	7	25	79	206	3	6	+368		4.3	3.0	26	6.2	
1	2	7	25	79	206	1	5	+314	+338	4.0	3.0	24	6.1	+529
1	2	7	25	79	206	1	6	+334		4.0	3.0	24	6.1	
1	2	7	25	79	206	2	5	+321		4.0	3.0	24	6.1	
1	2	7	25	79	206	2	6	+342		4.0	3.0	24	6.1	
1	2	7	25	79	206	1	5	+305	+321	3.7	3.0	21	6.2	+522
1	2	7	25	79	206	1	6	+302		3.7	3.0	21	6.2	
1	2	7	25	79	206	2	5	+320		3.7	3.0	21	6.2	
1	2	7	25	79	206	2	6	+321		3.7	3.0	21	6.2	
1	2	7	25	79	206	3	5	+323		3.7	3.0	21	6.2	
1	2	7	25	79	206	3	6	+322		3.7	3.0	21	6.2	
1	2	7	25	79	206	1	5	+268	+236	3.4	3.0	17	7.4	+560
1	2	7	25	79	206	1	6	+269		3.4	3.0	17	7.4	
1	2	7	25	79	206	2	5	+289		3.4	3.0	17	7.4	
1	2	7	25	79	206	2	6	+289		3.4	3.0	17	7.4	
1	2	7	25	79	206	3	5	+296		3.4	3.0	17	7.4	
1	2	7	25	79	206	3	6	+299		3.4	3.0	17	7.4	
1	2	7	25	79	206	1	5	+177	+160	3.1	3.0	17	7.8	+458
1	2	7	25	79	206	2	5	+164		3.1	3.0	17	7.8	
1	2	7	25	79	206	3	5	+156		3.1	3.0	17	7.8	
1	2	12	15	79	349	1	5	+342	+340	4.3	3.1	0	6.2	+556
1	2	12	15	79	349	2	5	+338		4.3	3.1	0	6.2	
1	2	12	15	79	349	1	5	+389	+337	4.0	3.1	1	6.1	+597
1	2	12	15	79	349	2	5	+385		4.0	3.1	1	6.1	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	FCAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
1	2	12	15	79	349	1	5	+295	+297	3.7	3.1	2	6.2	+512
1	2	12	15	79	349	2	5	+299		3.7	3.1	2	6.2	
1	2	12	15	79	349	1	5	+264	+266	3.4	3.1	5	7.4	+561
1	2	12	15	79	349	2	5	+267		3.4	3.1	5	7.4	
1	2	12	15	79	349	1	5	+254	+250	3.1	3.1	6	7.8	+556
1	2	12	15	79	349	2	5	+246		3.1	3.1	6	7.8	
1	2	5	4	80	124	1	5	+334	+332	4.3	2.4	7	6.2	+544
1	2	5	4	80	124	2	5	+330		4.3	2.4	7	6.2	
1	2	5	4	80	124	3	5	+341		4.3	2.4	7	6.2	
1	2	5	4	80	124	1	5	+374	+377	4.0	2.4	3	6.1	+585
1	2	5	4	80	124	2	5	+381		4.0	2.4	3	6.1	
1	2	5	4	80	124	3	5	+377		4.0	2.4	3	6.1	
1	2	5	4	80	124	1	5	+308	+311	3.7	2.4	5	6.2	+524
1	2	5	4	80	124	2	5	+310		3.7	2.4	5	6.2	
1	2	5	4	80	124	3	5	+316		3.7	2.4	5	6.2	
1	2	5	4	80	124	1	5	+264	+270	3.4	2.4	5	7.4	+553
1	2	5	4	80	124	2	5	+269		3.4	2.4	5	7.4	
1	2	5	4	80	124	3	5	+277		3.4	2.4	5	7.4	
1	2	5	4	80	124	1	5	+250	+246	3.1	2.4	5	7.8	+542
1	2	5	4	80	124	2	5	+246		3.1	2.4	5	7.8	
1	2	5	4	80	124	3	5	+241		3.1	2.4	5	7.3	
1	3	6	13	79	164	1	5	+272	+271	3.4	2.3	23	6.3	+476
1	3	6	13	79	164	1	6	+274		3.4	2.3	23	6.3	
1	3	6	13	79	164	2	5	+263		3.4	2.3	23	6.3	
1	3	6	13	79	164	2	6	+268		3.4	2.3	23	6.3	

TRY	SS	MONTH	DAY	YEAR	DAYYEAR	ELNU	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	3	6	13	79	164	1	5	+273	+266	3.1	2.3	20	6.8	+503
1	3	6	13	79	164	1	6	+274		3.1	2.3	20	6.8	
1	3	6	13	79	164	2	5	+258		3.1	2.3	20	6.8	
1	3	6	13	79	164	2	6	+257		3.1	2.3	20	6.8	
1	3	6	13	79	164	1	5	+247	+252	2.8	2.3	19	7.5	+531
1	3	6	13	79	164	1	6	+249		2.8	2.3	19	7.5	
1	3	6	13	79	164	2	5	+256		2.8	2.3	19	7.5	
1	3	6	13	79	164	2	6	+256		2.8	2.3	19	7.5	
1	3	6	13	79	164	1	5	+237	+241	2.5	2.3	17	7.7	+532
1	3	6	13	79	164	1	6	+238		2.5	2.3	17	7.7	
1	3	6	13	79	164	2	5	+243		2.5	2.3	17	7.7	
1	3	6	13	79	164	2	6	+243		2.5	2.3	17	7.7	
1	3	6	13	79	164	1	5	+199	+189	2.2	2.3	15	7.7	+482
1	3	6	13	79	164	1	6	+197		2.2	2.3	15	7.7	
1	3	6	13	79	164	2	5	+179		2.2	2.3	15	7.7	
1	3	6	13	79	164	2	6	+184		2.2	2.3	15	7.7	
1	3	6	13	79	164	2	7	+185		2.2	2.3	15	7.7	
1	3	7	25	79	206	1	5	+297	+313	3.4	2.3	26	6.3	+515
1	3	7	25	79	206	1	6	+294		3.4	2.3	26	6.3	
1	3	7	25	79	206	2	5	+311		3.4	2.3	26	6.3	
1	3	7	25	79	206	2	6	+315		3.4	2.3	23	6.3	
1	3	7	25	79	206	3	7	+329		3.4	2.3	23	6.3	
1	3	7	25	79	206	3	8	+330		3.4	2.3	23	6.3	
1	3	7	25	79	206	1	5	+301	+303	3.1	2.3	24	6.8	+535
1	3	7	25	79	206	1	6	+302		3.1	2.3	24	6.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	3	7	25	79	206	2	5	+304		3.1	2.3	24	6.8	
1	3	7	25	79	206	2	6	+304		3.1	2.3	24	6.8	
1	3	7	25	79	206	3	4	+320		3.1	2.3	24	6.8	
1	3	7	25	79	206	3	5	+320		3.1	2.3	24	6.8	
1	3	7	25	79	206	1	5	+311	+318	2.8	2.3	21	7.5	+595
1	3	7	25	79	206	1	6	+317		2.8	2.3	21	7.5	
1	3	7	25	79	206	2	4	+305		2.8	2.3	21	7.5	
1	3	7	25	79	206	2	5	+306		2.8	2.3	21	7.5	
1	3	7	25	79	206	3	4	+318		2.8	2.3	21	7.5	
1	3	7	25	79	206	3	5	+319		2.8	2.3	21	7.5	
1	3	7	25	79	206	1	5	+029	+062	2.5	2.3	17	7.7	+353
1	3	7	25	79	206	1	6	+025		2.5	2.3	17	7.7	
1	3	7	25	79	206	2	6	+066		2.5	2.3	17	7.7	
1	3	7	25	79	206	2	7	+067		2.5	2.3	17	7.7	
1	3	7	25	79	206	3	6	+095		2.5	2.3	17	7.7	
1	3	7	25	79	206	3	7	+096		2.5	2.3	17	7.7	
1	3	7	25	79	206	1	5	-074	-094	2.2	2.3	17	7.7	+197
1	3	7	25	79	206	2	5	-097		2.2	2.3	17	7.7	
1	3	7	25	79	206	3	5	-110		2.2	2.3	17	7.7	
1	3	12	15	79	349	1	5	+247	+245	3.4	2.6	0	6.3	+407
1	3	12	15	79	349	2	5	+243		3.4	2.6	0	6.3	
1	3	12	15	79	349	1	5	+237	+238	3.1	2.6	1	6.8	+489
1	3	12	15	79	349	2	5	+239		3.1	2.6	1	6.8	
1	3	12	15	79	349	1	5	+159	+160	2.8	2.6	2	7.5	+451
1	3	12	15	79	349	2	5	+161		2.8	2.6	2	7.5	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
1	3	12	15	79	349	1	5	+337	+345	2.5	2.6	5	7.7	+646
1	3	12	15	79	349	2	5	+353		2.5	2.6	5	7.7	
1	3	12	15	79	349	1	5	+211	+212	2.2	2.6	6	7.7	+512
1	3	12	15	79	349	2	5	+213		2.2	2.6	6	7.7	
1	3	5	4	80	124	1	5	+181	+180	3.4	2.7	7	6.3	+396
1	3	5	4	80	124	2	5	+177		3.4	2.7	7	6.3	
1	3	5	4	80	124	3	5	+183		3.4	2.7	7	6.3	
1	3	5	4	80	124	1	5	+256	+245	3.1	2.7	5	6.8	+493
1	3	5	4	80	124	2	5	+241		3.1	2.7	5	6.8	
1	3	5	4	80	124	3	5	+237		3.1	2.7	5	6.8	
1	3	5	4	80	124	1	5	+206	+202	2.8	2.7	5	7.5	+492
1	3	5	4	80	124	2	5	+198		2.8	2.7	5	7.5	
1	3	5	4	80	124	3	5	+201		2.8	2.7	5	7.5	
1	3	5	4	80	124	1	5	+227	+213	2.5	2.7	5	7.7	+513
1	3	5	4	80	124	2	5	+210		2.5	2.7	5	7.7	
1	3	5	4	80	124	3	5	+201		2.5	2.7	5	7.7	
1	3	5	4	80	124	1	5	+271	+202	2.2	2.7	5	7.7	+503
1	3	5	4	80	124	2	5	+260		2.2	2.7	5	7.7	
1	3	5	4	80	124	3	5	+274		2.2	2.7	5	7.7	
1	4	6	13	79	164	1	5	+260	+278	3.1	2.5	22	7.4	+549
1	4	6	13	79	164	1	6	+264		3.1	2.5	22	7.4	
1	4	6	13	79	164	2	5	+293		3.1	2.5	22	7.4	
1	4	6	13	79	164	2	6	+292		3.1	2.5	22	7.4	
1	4	6	13	79	164	1	5	+260	+267	2.8	2.5	20	7.4	+539
1	4	6	13	79	164	1	6	+262		2.8	2.5	20	7.4	

TRY	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	LH
1	4	6	13	79	164	2	5	+272		2.8	2.5	20	7.4	
1	4	6	13	79	164	2	6	+274		2.8	2.5	20	7.4	
1	4	6	13	79	164	1	5	+226	+158	2.5	2.5	17	7.4	+431
1	4	6	13	79	164	1	6	+224		2.5	2.5	17	7.4	
1	4	6	13	79	164	2	5	+139		2.5	2.5	17	7.4	
1	4	6	13	79	164	2	6	+140		2.5	2.5	17	7.4	
1	4	6	13	79	164	3	5	+097		2.5	2.5	17	7.4	
1	4	6	13	79	164	3	6	+091		2.5	2.5	17	7.4	
1	4	6	13	79	164	1	5	+066	-335	2.2	2.5	17	7.4	-112
1	4	6	13	79	164	1	6	+076		2.2	2.5	17	7.4	
1	4	6	13	79	164	1	7	+083		2.2	2.5	17	7.4	
1	4	6	13	79	164	2	5	-346		2.2	2.5	17	7.4	
1	4	6	13	79	164	2	6	-355		2.2	2.5	17	7.4	
1	4	6	13	79	164	2	7	-356		2.2	2.5	17	7.4	
1	4	6	13	79	164	3	5	-470		2.2	2.5	17	7.4	
1	4	6	13	79	164	3	6	-440		2.2	2.5	17	7.4	
1	4	6	13	79	164	3	7	-413		2.2	2.5	17	7.4	
1	4	6	13	79	164	3	9	-350		2.2	2.5	17	7.4	
1	4	6	13	79	164	1	5	-316	-317	1.9	2.5	15	7.4	-068
1	4	6	13	79	164	2	5	-319		1.9	2.5	15	7.4	
1	4	6	13	79	164	3	5	-317		1.9	2.5	15	7.4	
1	4	7	25	79	206	1	6	+311	+321	3.1	2.5	26	7.3	+584
1	4	7	25	79	206	1	7	+314		3.1	2.5	26	7.3	
1	4	7	25	79	206	2	6	+324		3.1	2.5	26	7.3	
1	4	7	25	79	206	2	7	+324		3.1	2.5	26	7.3	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNU	TIMEMIN	ECAL	AVECAL	DEHABL	O*TABL	TEMP	PH	EH
1	4	7	25	79	206	3	6	+326		3.1	2.5	26	7.3	
1	4	7	25	79	206	3	7	+328		3.1	2.5	26	7.3	
1	4	7	25	79	206	1	5	+284	+295	2.8	2.5	24	7.4	+564
1	4	7	25	79	206	1	6	+285		2.8	2.5	24	7.4	
1	4	7	25	79	206	2	5	+304		2.8	2.5	24	7.4	
1	4	7	25	79	206	2	6	+306		2.8	2.5	24	7.4	
1	4	7	25	79	206	3	5	+294		2.8	2.5	24	7.4	
1	4	7	25	79	206	3	6	+298		2.8	2.5	24	7.4	
1	4	7	25	79	206	1	4	+293	+301	2.5	2.5	21	7.4	+573
1	4	7	25	79	206	1	5	+295		2.5	2.5	21	7.4	
1	4	7	25	79	206	2	4	+306		2.5	2.5	21	7.4	
1	4	7	25	79	206	2	5	+307		2.5	2.5	21	7.4	
1	4	7	25	79	206	3	5	+301		2.5	2.5	21	7.4	
1	4	7	25	79	206	3	6	+303		2.5	2.5	21	7.4	
1	4	7	25	79	206	1	6	+241	+241	2.2	2.5	17	7.4	+514
1	4	7	25	79	206	1	7	+242		2.2	2.5	17	7.4	
1	4	7	25	79	206	2	5	+279		2.2	2.5	17	7.4	
1	4	7	25	79	206	2	6	+289		2.2	2.5	17	7.4	
1	4	7	25	79	206	3	6	+198		2.2	2.5	17	7.4	
1	4	7	25	79	206	3	7	+197		2.2	2.5	17	7.4	
1	4	7	25	79	206	1	7	-397	-347	1.9	2.5	17	7.4	-051
1	4	7	25	79	206	1	6	-375		1.9	2.5	17	7.4	
1	4	7	25	79	206	2	5	-372		1.9	2.5	17	7.4	
1	4	7	25	79	206	2	6	-369		1.9	2.5	17	7.4	
1	4	7	25	79	206	3	7	-236		1.9	2.5	17	7.4	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNC	TIMEMIN	ECAL	AVECAL	DEHAEL	D*TAUL	TEMP	PH	EH
1	4	7	25	79	206	3	8	-284		1.9	2.5	17	7.4	
1	4	12	15	79	349	1	5	+284	+256	3.1	2.5	0	7.3	+537
1	4	12	15	79	349	2	5	+227		3.1	2.5	0	7.3	
1	4	12	15	79	349	1	5	+323	+325	2.8	2.5	1	7.4	+611
1	4	12	15	79	349	2	5	+327		2.8	2.5	1	7.4	
1	4	12	15	79	349	1	5	+356	+356	2.5	2.5	2	7.4	+642
1	4	12	15	79	349	2	5	+354		2.5	2.5	2	7.4	
1	4	12	15	79	349	1	5	+338	+338	2.2	2.5	5	7.4	+621
1	4	12	15	79	349	2	5	+338		2.2	2.5	5	7.4	
1	4	12	15	79	349	1	5	+287	+286	1.9	2.5	6	7.4	+569
1	4	12	15	79	349	2	5	+285		1.9	2.5	6	7.4	
1	4	5	4	80	124	1	5	+173	+177	3.1	2.3	7	7.3	+445
1	4	5	4	80	124	2	5	+181		3.1	2.3	7	7.3	
1	4	5	4	80	124	3	5	+167		3.1	2.3	7	7.3	
1	4	5	4	80	124	1	5	+191	+185	2.8	2.3	5	7.4	+468
1	4	5	4	80	124	2	5	+178		2.8	2.3	5	7.4	
1	4	5	4	80	124	3	5	+187		2.8	2.3	5	7.4	
1	4	5	4	80	124	1	5	+207	+205	2.5	2.3	5	7.4	+465
1	4	5	4	80	124	2	5	+197		2.5	2.3	5	7.4	
1	4	5	4	80	124	3	5	+210		2.5	2.3	5	7.4	
1	4	5	4	80	124	1	5	+006	+011	2.2	2.3	6	7.4	+294
1	4	5	4	80	124	2	5	+018		2.2	2.3	6	7.4	
1	4	5	4	80	124	3	5	+010		2.2	2.3	6	7.4	
1	4	5	4	80	124	1	5	+147	+145	1.9	2.3	6	7.4	+428
1	4	5	4	80	124	2	5	+145		1.9	2.3	6	7.4	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	4	5	4	80	124	3	5	+157		1.9	2.3	6	7.4	
1	5	6	13	79	164	1	5	+261	+262	2.7	2.0	23	7.4	+532
1	5	6	13	79	164	1	6	+263		2.7	2.0	23	7.4	
1	5	6	13	79	164	2	5	+262		2.7	2.0	23	7.4	
1	5	6	13	79	164	2	6	+263		2.7	2.0	23	7.4	
1	5	6	13	79	164	1	5	+257	+265	2.4	2.0	21	7.6	+548
1	5	6	13	79	164	1	6	+257		2.4	2.0	21	7.6	
1	5	6	13	79	164	2	5	+271		2.4	2.0	21	7.6	
1	5	6	13	79	164	2	6	+274		2.4	2.0	21	7.6	
1	5	6	13	79	164	3	5	+262		2.4	2.0	21	7.6	
1	5	6	13	79	164	3	6	+268		2.4	2.0	21	7.6	
1	5	6	13	79	164	1	5	+136	+132	2.1	2.0	19	7.7	+422
1	5	6	13	79	164	1	6	+137		2.1	2.0	19	7.7	
1	5	6	13	79	164	2	5	+126		2.1	2.0	19	7.7	
1	5	6	13	79	164	2	6	+129		2.1	2.0	19	7.7	
1	5	6	13	79	164	1	5	+125	+123	1.8	2.0	15	7.7	+421
1	5	6	13	79	164	1	6	+123		1.8	2.0	15	7.7	
1	5	6	13	79	164	2	5	+129		1.8	2.0	15	7.7	
1	5	6	13	79	164	2	6	+134		1.8	2.0	15	7.7	
1	5	6	13	79	164	1	5	-042	-041	1.5	2.0	14	7.8	+258
1	5	6	13	79	164	1	6	-044		1.5	2.0	14	7.8	
1	5	6	13	79	164	2	5	-037		1.5	2.0	14	7.8	
1	5	6	13	79	164	2	6	-039		1.5	2.0	14	7.8	
1	5	7	25	79	206	1	6	+235	+249	2.7	1.6	26	7.4	+518
1	5	7	25	79	206	1	7	+237		2.7	1.6	26	7.4	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	CH
1	5	7	25	79	206	2	4	+249		2.7	1.6	26	7.4	
1	5	7	25	79	206	2	5	+250		2.7	1.6	26	7.4	
1	5	7	25	79	206	3	6	+261		2.7	1.6	26	7.4	
1	5	7	25	79	206	3	7	+261		2.7	1.6	26	7.4	
1	5	7	25	79	206	1	6	+262	+259	2.4	1.6	24	7.6	+540
1	5	7	25	79	206	1	7	+263		2.4	1.6	24	7.6	
1	5	7	25	79	206	2	5	+251		2.4	1.6	24	7.6	
1	5	7	25	79	206	2	6	+253		2.4	1.6	24	7.6	
1	5	7	25	79	206	3	6	+264		2.4	1.6	24	7.6	
1	5	7	25	79	206	3	7	+262		2.4	1.6	24	7.6	
1	5	7	25	79	206	1	7	+232	+220	2.1	1.6	21	7.7	+509
1	5	7	25	79	206	1	8	+234		2.1	1.6	21	7.7	
1	5	7	25	79	206	2	6	+240		2.1	1.6	21	7.7	
1	5	7	25	79	206	2	7	+241		2.1	1.6	21	7.7	
1	5	7	25	79	206	3	6	+186		2.1	1.6	21	7.7	
1	5	7	25	79	206	3	7	+186		2.1	1.6	21	7.7	
1	5	7	25	79	206	1	5	+222	+213	1.8	1.6	17	7.7	+505
1	5	7	25	79	206	1	6	+224		1.8	1.6	17	7.7	
1	5	7	25	79	206	2	6	+231		1.8	1.6	17	7.7	
1	5	7	25	79	206	2	7	+233		1.8	1.6	17	7.7	
1	5	7	25	79	206	3	5	+183		1.8	1.6	17	7.7	
1	5	7	25	79	206	3	6	+185		1.8	1.6	17	7.7	
1	5	7	25	79	206	1	3	-324	-387	1.5	1.6	17	7.8	- 39
1	5	7	25	79	206	1	4	-326		1.5	1.5	17	7.8	
1	5	7	25	79	206	2	6	-320		1.5	1.6	17	7.3	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
1	5	7	25	79	206	2	7	-321		1.5	1.6	17	7.8	
1	5	7	25	79	206	3	5	-515		1.5	1.6	17	7.8	
1	5	7	25	79	206	3	6	-517		1.5	1.6	17	7.8	
1	5	12	15	79	349	1	5	+259	+256	2.7	2.0	0	7.4	+543
1	5	12	15	79	349	2	5	+253		2.7	2.0	0	7.4	
1	5	12	15	79	349	1	5	+247	+244	2.4	2.0	1	7.6	+542
1	5	12	15	79	349	2	5	+241		2.4	2.0	1	7.6	
1	5	12	15	79	349	1	5	+231	+235	2.1	2.0	2	7.7	+538
1	5	12	15	79	349	2	5	+239		2.1	2.0	2	7.7	
1	5	12	15	79	349	1	5	+129	+131	1.8	2.0	5	7.7	+432
1	5	12	15	79	349	2	5	+133		1.8	2.0	5	7.7	
1	5	12	15	79	349	1	5	+126	+123	1.5	2.0	6	7.8	+430
1	5	12	15	79	349	2	5	+119		1.5	2.0	6	7.8	
1	5	5	4	80	124	1	5	+229	+235	2.7	1.9	6	7.4	+518
1	5	5	4	80	124	2	5	+239		2.7	1.9	6	7.4	
1	5	5	4	80	124	3	5	+237		2.7	1.9	6	7.4	
1	5	5	4	80	124	1	5	+257	+264	2.4	1.9	5	7.6	+560
1	5	5	4	80	124	2	5	+262		2.4	1.9	5	7.6	
1	5	5	4	80	124	3	5	+272		2.4	1.9	5	7.6	
1	5	5	4	80	124	1	5	+216	+212	2.1	1.9	5	7.7	+514
1	5	5	4	80	124	2	5	+209		2.1	1.9	5	7.7	
1	5	5	4	80	124	3	5	+210		2.1	1.9	5	7.7	
1	5	5	4	80	124	1	5	+215	+217	1.8	1.9	5	7.7	+519
1	5	5	4	80	124	2	5	+217		1.8	1.9	5	7.7	
1	5	5	4	80	124	3	5	+219		1.8	1.9	5	7.7	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	5	5	4	80	124	1	5	+237	-003	1.5	1.9	5	7.8	+310
1	5	5	4	80	124	2	5	-119		1.5	1.9	5	7.8	
1	5	5	4	80	124	3	5	-128		1.5	1.9	5	7.8	
1	6	6	13	79	164	1	5	+279	+232	2.5	2.0	21	7.4	+503
1	6	6	13	79	164	1	6	+281		2.5	2.0	21	7.4	
1	6	6	13	79	164	2	5	+286		2.5	2.0	21	7.4	
1	6	6	13	79	164	2	6	+281		2.5	2.0	21	7.4	
1	6	6	13	79	164	1	5	+259	+249	2.2	2.0	19	7.5	+528
1	6	6	13	79	164	1	6	+259		2.2	2.0	19	7.5	
1	6	6	13	79	164	2	5	+241		2.2	2.0	19	7.5	
1	6	6	13	79	164	2	6	+237		2.2	2.0	19	7.5	
1	6	6	13	79	164	1	5	+246	+243	1.9	2.0	17	7.6	+529
1	6	6	13	79	164	1	6	+244		1.9	2.0	17	7.6	
1	6	6	13	79	164	2	5	+257		1.9	2.0	17	7.6	
1	6	6	13	79	164	2	6	+245		1.9	2.0	17	7.6	
1	6	6	13	79	164	1	5	+240	+245	1.6	2.0	16	7.6	+532
1	6	6	13	79	164	1	6	+239		1.6	2.0	16	7.6	
1	6	6	13	79	164	2	5	+242		1.6	2.0	16	7.6	
1	6	6	13	79	164	2	6	+257		1.6	2.0	16	7.6	
1	6	6	13	79	164	1	5	-175	-184	1.3	2.0	15	7.5	+104
1	6	6	13	79	164	1	6	-169		1.3	2.0	15	7.6	
1	6	6	13	79	164	2	5	-194		1.3	2.0	15	7.6	
1	6	6	13	79	164	2	6	-197		1.3	2.0	15	7.6	
1	6	7	25	79	206	1	5	+237	+233	2.5	2.2	26	7.4	+507
1	6	7	25	79	206	1	6	+239		2.5	2.2	26	7.4	

TRY	SS	MONTH	DAY	YEAR	DAYYEAR	FLNC	TIMEMIN	ECAL	AVECAL	DEHABL	D.TABL	TEMP	PH	EH
1	6	7	25	79	206	2	5	+238		2.5	2.2	26	7.4	
1	6	7	25	79	206	2	6	+237		2.5	2.2	26	7.4	
1	6	7	25	79	206	3	5	+240		2.5	2.2	26	7.4	
1	6	7	25	79	206	3	6	+241		2.5	2.2	26	7.4	
1	6	7	25	79	206	1	7	+308	+316	2.2	2.2	25	7.5	+590
1	6	7	25	79	206	1	8	+307		2.2	2.2	25	7.5	
1	6	7	25	79	206	2	3	+316		2.2	2.2	25	7.5	
1	6	7	25	79	206	2	4	+318		2.2	2.2	25	7.5	
1	6	7	25	79	206	3	5	+323		2.2	2.2	25	7.5	
1	6	7	25	79	206	3	6	+321		2.2	2.2	25	7.5	
1	6	7	25	79	206	1	6	+323	+254	1.9	2.2	22	7.6	+535
1	6	7	25	79	206	1	7	+324		1.9	2.2	22	7.6	
1	6	7	25	79	206	2	5	+267		1.9	2.2	22	7.6	
1	6	7	25	79	206	2	6	+269		1.9	2.2	22	7.6	
1	6	7	25	79	206	3	6	+198		1.9	2.2	22	7.6	
1	6	7	25	79	206	3	7	+200		1.9	2.2	22	7.6	
1	6	7	25	79	206	1	6	-110	-410	1.6	2.2	18	7.6	-126
1	6	7	25	79	206	1	7	-110		1.6	2.2	18	7.6	
1	6	7	25	79	206	2	8	-514		1.6	2.2	18	7.6	
1	6	7	25	79	206	2	9	-515		1.6	2.2	18	7.6	
1	6	7	25	79	206	3	5	-609		1.6	2.2	18	7.6	
1	6	7	25	79	206	3	6	-607		1.6	2.2	18	7.6	
1	6	7	25	79	206	1	5	-131	-157	1.3	2.2	18	7.6	+127
1	6	7	25	79	206	1	6	-138		1.3	2.2	18	7.6	
1	6	7	25	79	206	2	5	-147		1.3	2.2	18	7.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	6	7	25	79	206	2	6	-158		1.3	2.2	18	7.6	
1	6	7	25	79	206	3	5	-172		1.3	2.2	18	7.6	
1	6	7	25	79	206	3	6	-194		1.3	2.2	18	7.6	
1	6	12	15	79	349	1	5	+256	+253	2.5	1.8	0	7.4	+540
1	6	12	15	79	349	2	5	+249		2.5	1.8	0	7.4	
1	6	12	15	79	349	1	5	+287	+288	2.2	1.8	1	7.5	+560
1	6	12	15	79	349	2	5	+289		2.2	1.8	1	7.5	
1	6	12	15	79	349	1	5	-076	-072	1.9	1.8	2	7.6	+226
1	6	12	15	79	349	2	5	-067		1.9	1.8	2	7.6	
1	6	12	15	79	349	1	5	-051	-055	1.6	1.8	5	7.6	+240
1	6	12	15	79	349	2	5	-059		1.6	1.8	5	7.6	
1	6	12	15	79	349	1	5	-049	-044	1.3	1.8	6	7.6	+250
1	6	12	15	79	349	2	5	-039		1.3	1.8	6	7.6	
1	6	5	4	80	124	1	5	+207	+216	2.5	1.9	6	7.4	+459
1	6	5	4	80	124	2	5	+217		2.5	1.9	6	7.4	
1	6	5	4	80	124	3	5	+224		2.5	1.9	6	7.4	
1	6	5	4	80	124	1	5	+214	+213	2.2	1.9	6	7.5	+501
1	6	5	4	80	124	2	5	+216		2.2	1.9	6	7.5	
1	6	5	4	80	124	3	5	+208		2.2	1.9	6	7.5	
1	6	5	4	80	124	1	5	+227	+219	1.9	1.9	5	7.6	+514
1	6	5	4	80	124	2	5	+218		1.9	1.9	5	7.6	
1	6	5	4	80	124	3	5	+212		1.9	1.9	5	7.6	
1	6	5	4	80	124	1	5	+181	+180	1.6	1.9	5	7.6	+475
1	6	5	4	80	124	2	5	+171		1.6	1.9	5	7.6	
1	6	5	4	80	124	3	5	+189		1.6	1.9	5	7.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
1	6	5	4	80	124	1	5	+085	+073	1.3	1.9	5	7.6	+368
1	6	5	4	80	124	2	5	+071		1.3	1.9	5	7.6	
1	6	5	4	80	124	3	5	+063		1.3	1.9	5	7.6	
2	1	6	6	79	157	1	5	+365	+365	3.9	2.7	20	6.1	+361
2	1	6	6	79	157	2	5	+363		3.9	2.7	20	6.1	
2	1	6	6	79	157	3	5	+366		3.9	2.7	20	6.1	
2	1	6	6	79	157	1	5	+124	+132	3.6	2.7	18	5.9	+375
2	1	6	6	79	157	2	5	+139		3.6	2.7	18	5.9	
2	1	6	6	79	157	3	5	+264		3.6	2.7	18	5.9	
2	1	6	6	79	157	1	5	+283	+268	3.3	2.7	16	7.1	+525
2	1	6	6	79	157	2	5	+139		3.3	2.7	16	7.1	
2	1	6	6	79	157	3	5	+254		3.3	2.7	16	7.1	
2	1	6	6	79	157	1	5	+180	+174	3.0	2.7	14	7.8	+473
2	1	6	6	79	157	2	5	+168		3.0	2.7	14	7.8	
2	1	6	6	79	157	3	5	+138		3.0	2.7	14	7.6	
2	1	6	6	79	157	1	5	+233	+277	2.7	2.7	13	7.6	+578
2	1	6	6	79	157	1	6	+286		2.7	2.7	13	7.6	
2	1	6	6	79	157	1	7	+265		2.7	2.7	13	7.6	
2	1	6	6	79	157	2	5	+268		2.7	2.7	13	7.8	
2	1	6	6	79	157	2	6	+230		2.7	2.7	13	7.6	
2	1	6	6	79	157	2	7	+269		2.7	2.7	13	7.8	
2	1	6	6	79	157	3	8	+258		2.7	2.7	13	7.6	
2	1	6	6	79	157	3	9	+266		2.7	2.7	13	7.8	
2	1	6	22	79	173	1	3	+350	+351	3.9	2.5	26	6.1	+543
2	1	6	22	79	173	1	4	+350		3.9	2.5	26	6.1	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	1	6	22	79	173	2	3	+357		3.9	2.5	26	6.1	
2	1	6	22	79	173	2	4	+356		3.9	2.5	26	6.1	
2	1	6	22	79	173	3	5	+345		3.9	2.5	26	6.1	
2	1	6	22	79	173	3	6	+348		3.9	2.5	26	6.1	
2	1	6	22	79	173	1	4	+304	+303	3.6	2.5	19	5.9	+437
2	1	6	22	79	173	1	5	+303		3.6	2.5	19	5.9	
2	1	6	22	79	173	2	4	+316		3.6	2.5	19	5.9	
2	1	6	22	79	173	2	5	+317		3.6	2.5	19	5.9	
2	1	6	22	79	173	3	4	+302		3.6	2.5	19	5.9	
2	1	6	22	79	173	3	5	+303		3.6	2.5	19	5.9	
2	1	6	22	79	173	1	4	+288	+293	3.3	2.5	16	7.1	+550
2	1	6	22	79	173	1	5	+287		3.3	2.5	16	7.1	
2	1	6	22	79	173	2	3	+298		3.3	2.5	16	7.1	
2	1	6	22	79	173	2	5	+290		3.3	2.5	16	7.1	
2	1	6	22	79	173	3	4	+292		3.3	2.5	16	7.1	
2	1	6	22	79	173	3	5	+291		3.3	2.5	16	7.1	
2	1	6	22	79	173	1	4	+292	+293	3.0	2.5	15	7.8	+592
2	1	6	22	79	173	1	5	+292		3.0	2.5	15	7.8	
2	1	6	22	79	173	2	4	+288		3.0	2.5	15	7.8	
2	1	6	22	79	173	2	5	+289		3.0	2.5	15	7.8	
2	1	6	22	79	173	3	4	+298		3.0	2.5	15	7.8	
2	1	6	22	79	173	3	5	+296		3.0	2.5	15	7.8	
2	1	6	22	79	173	1	4	+259	+265	2.7	2.5	15	7.8	+564
2	1	6	22	79	173	1	5	+260		2.7	2.5	15	7.8	
2	1	6	22	79	173	2	2	+265		2.7	2.5	15	7.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	CELL	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	1	6	22	79	173	2	3	+266		2.7	2.5	15	7.8	
2	1	6	22	79	173	3	2	+263		2.7	2.5	15	7.8	
2	1	6	22	79	173	3	3	+269		2.7	2.5	15	7.8	
2	1	7	27	79	208	1	5	+385	+391	3.9	2.5	26	6.1	+583
2	1	7	27	79	208	1	6	+386		3.9	2.5	26	6.1	
2	1	7	27	79	208	2	5	+397		3.9	2.5	26	6.1	
2	1	7	27	79	208	2	6	+396		3.9	2.5	26	6.1	
2	1	7	27	79	208	3	5	+279		3.9	2.5	26	6.1	
2	1	7	27	79	208	3	6	+281		3.9	2.5	26	6.1	
2	1	7	27	79	208	1	5	+354	+342	3.6	2.5	24	5.9	+522
2	1	7	27	79	208	1	6	+355		3.6	2.5	24	5.9	
2	1	7	27	79	208	2	5	+327		3.6	2.5	24	5.9	
2	1	7	27	79	208	3	6	+328		3.6	2.5	24	5.9	
2	1	7	27	79	208	3	4	+233		3.6	2.5	24	5.9	
2	1	7	27	79	208	3	5	+233		3.6	2.5	24	5.9	
2	1	7	27	79	208	1	4	+307	+313	3.3	2.5	21	7.1	+499
2	1	7	27	79	208	1	5	+309		3.3	2.5	21	7.1	
2	1	7	27	79	208	2	5	+317		3.3	2.5	21	7.1	
2	1	7	27	79	208	2	6	+318		3.3	2.5	21	7.1	
2	1	7	27	79	208	3	4	+239		3.3	2.5	21	7.1	
2	1	7	27	79	208	3	5	+238		3.3	2.5	21	7.1	
2	1	7	27	79	208	1	5	+293	+271	3.0	2.5	17	7.8	+508
2	1	7	27	79	208	1	6	+295		3.0	2.5	17	7.8	
2	1	7	27	79	208	2	7	+293		3.0	2.5	17	7.8	
2	1	7	27	79	208	2	8	+297		3.0	2.5	17	7.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	LH
2	1	7	27	79	208	3	5	+224		2.7	2.5	17	7.8	
2	1	7	27	79	208	3	6	+226		2.7	2.5	17	7.8	
2	1	7	27	79	208	1	5	+274	+276	2.7	2.5	17	7.8	+574
2	1	7	27	79	208	1	6	+278		2.7	2.5	17	7.8	
2	1	7	27	79	208	2	7	-005		2.7	2.5	17	7.8	
2	1	7	27	79	208	2	6	-008		2.7	2.5	17	7.8	
2	1	7	27	79	208	3	7	+163		2.7	2.5	17	7.8	
2	1	7	27	79	208	3	8	+154		2.7	2.5	17	7.8	
2	1	12	24	79	358	1	5	+472	+471	3.9	2.1	0	6.1	+602
2	1	12	24	79	358	2	5	+470		3.9	2.1	0	6.1	
2	1	12	24	79	358	1	5	+455	+455	3.6	2.1	1	5.9	+652
2	1	12	24	79	358	2	5	+454		3.6	2.1	1	5.9	
2	1	12	24	79	358	1	5	+249	+248	3.3	2.1	2	7.1	+569
2	1	12	24	79	358	2	5	+247		3.3	2.1	2	7.1	
2	1	12	24	79	358	1	5	+235	+234	3.0	2.1	3	7.8	+541
2	1	12	24	79	358	2	5	+233		3.0	2.1	3	7.0	
2	1	12	24	79	358	1	5	+199	+200	2.7	2.1	6	7.8	+506
2	1	12	24	79	358	2	5	+202		2.7	2.1	6	7.8	
2	1	5	6	80	126	1	5	+245	+249	3.9	2.3	7	6.1	+446
2	1	5	6	80	126	2	5	+254		3.9	2.3	7	6.1	
2	1	5	6	80	126	3	5	+248		3.9	2.3	7	6.1	
2	1	5	6	80	126	1	5	+247	+250	3.6	2.3	6	5.9	+444
2	1	5	6	80	126	2	5	+254		3.6	2.3	6	5.9	
2	1	5	6	80	126	3	5	+249		3.6	2.3	6	5.9	
2	1	5	6	80	126	1	5	+268	+265	3.3	2.3	3	7.1	+531

TRV	SS	MONTH	DAY	YEAR	LAYYEAR	ELNC	TIMEMIN	ECAL	AVECAL	OEHAGL	O.TAGL	TEMP	PH	EH
2	1	5	6	80	126	2	5	+254		3.3	2.3	5	7.1	
2	1	5	6	80	126	3	5	+272		3.3	2.3	5	7.1	
2	1	5	6	80	126	1	5	+249	+297	3.0	2.3	5	7.8	+604
2	1	5	6	80	126	2	5	+287		3.0	2.3	5	7.8	
2	1	5	6	80	126	3	5	+304		3.0	2.3	5	7.8	
2	1	5	6	80	126	1	5	+100	+194	2.7	2.3	5	7.8	+501
2	1	5	6	80	126	2	5	+235		2.7	2.3	5	7.8	
2	1	5	6	80	126	3	5	+247		2.7	2.3	5	7.8	
2	2	6	6	79	157	1	5	+311	+309	3.1	2.2	18	5.9	+493
2	2	6	6	79	157	2	5	+313		3.1	2.2	18	5.9	
2	2	6	6	79	157	3	5	+307		3.1	2.2	18	5.9	
2	2	6	6	79	157	3	6	+314		3.1	2.2	18	5.9	
2	2	6	6	79	157	1	5	+289	+271	2.8	2.2	17	6.6	+486
2	2	6	6	79	157	2	5	+253		2.8	2.2	17	6.6	
2	2	6	6	79	157	3	5	+267		2.8	2.2	17	6.6	
2	2	6	6	79	157	1	5	+248	+254	2.5	2.2	15	7.8	+554
2	2	6	6	79	157	1	6	+259		2.5	2.2	15	7.8	
2	2	6	6	79	157	1	7	+257		2.5	2.2	15	7.8	
2	2	6	6	79	157	2	5	+260		2.5	2.2	15	7.8	
2	2	6	6	79	157	3	5	+211		2.5	2.2	15	7.8	
2	2	6	6	79	157	1	5	-580	-602	2.2	2.2	14	7.8	-302
2	2	6	6	79	157	1	6	-596		2.2	2.2	14	7.8	
2	2	6	6	79	157	2	7	-592		2.2	2.2	14	7.8	
2	2	6	6	79	157	3	5	-625		2.2	2.2	14	7.8	
2	2	6	6	79	157	1	5	-590	-582	1.9	2.2	13	7.9	-275

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	LCAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
2	2	6	6	79	157	2	5	-570		1.9	2.2	13	7.9	
2	2	6	6	79	157	3	5	-565		1.9	2.2	13	7.9	
2	2	6	22	79	173	1	4	+320	+330	3.1	2.2	21	5.9	+513
2	2	6	22	79	173	1	3	+321		3.1	2.2	21	5.9	
2	2	6	22	79	173	2	4	+331		3.1	2.2	21	5.9	
2	2	6	22	79	173	2	5	+337		3.1	2.2	21	5.9	
2	2	6	22	79	173	3	4	+334		3.1	2.2	21	5.9	
2	2	6	22	79	173	3	5	+335		3.1	2.2	21	5.9	
2	2	6	22	79	173	1	4	+323	+326	2.8	2.2	18	6.6	+540
2	2	6	22	79	173	1	5	+324		2.8	2.2	18	6.6	
2	2	6	22	79	173	2	5	+327		2.8	2.2	18	6.6	
2	2	6	22	79	173	3	6	+329		2.8	2.2	18	6.6	
2	2	6	22	79	173	3	3	+326		2.8	2.2	18	6.6	
2	2	6	22	79	173	3	4	+327		2.8	2.2	18	6.6	
2	2	6	22	79	173	1	4	+296	+300	2.5	2.2	17	7.6	+598
2	2	6	22	79	173	1	5	+297		2.5	2.2	17	7.8	
2	2	6	22	79	173	2	3	+301		2.5	2.2	17	7.8	
2	2	6	22	79	173	2	4	+299		2.5	2.2	17	7.8	
2	2	6	22	79	173	3	3	+301		2.5	2.2	17	7.8	
2	2	6	22	79	173	3	4	+304		2.5	2.2	17	7.6	
2	2	6	22	79	173	1	4	+213	+212	2.2	2.2	16	7.8	+511
2	2	6	22	79	173	1	5	+211		2.2	2.2	16	[illegible]	
2	2	6	22	79	173	2	5	+206		2.2	2.2	16	7.6	
2	2	6	22	79	173	2	6	+208		2.2	2.2	16	7.9	
2	2	6	22	79	173	3	5	+217		2.2	2.2	16	7.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	2	6	22	79	173	3	4	+218		2.2	2.2	16	7.6	
2	2	6	22	79	173	1	3	+067	+133	1.9	2.2	15	7.9	+438
2	2	6	22	79	173	1	4	+089		1.9	2.2	15	7.9	
2	2	6	22	79	173	2	3	+144		1.9	2.2	15	7.9	
2	2	6	22	79	173	2	4	+144		1.9	2.2	15	7.9	
2	2	6	22	79	173	3	3	+166		1.9	2.2	15	7.9	
2	2	7	27	79	208	1	5	+324	+350	3.1	2.1	26	5.9	+530
2	2	7	27	79	208	1	6	+324		3.1	2.1	26	5.9	
2	2	7	27	79	208	2	5	+359		3.1	2.1	25	5.9	
2	2	7	27	79	208	2	6	+359		3.1	2.1	26	5.9	
2	2	7	27	79	208	3	6	+365		3.1	2.1	26	5.9	
2	2	7	27	79	208	3	7	+368		3.1	2.1	25	5.9	
2	2	7	27	79	208	1	5	+314	+329	2.8	2.1	24	6.6	+537
2	2	7	27	79	208	1	6	+334		2.8	2.1	24	6.6	
2	2	7	27	79	208	2	5	+321		2.8	2.1	24	6.6	
2	2	7	27	79	208	2	6	+346		2.8	2.1	24	6.6	
2	2	7	27	79	208	1	5	+300	+315	2.5	2.1	21	7.8	+610
2	2	7	27	79	208	1	6	+302		2.5	2.1	21	7.8	
2	2	7	27	79	208	2	5	+320		2.5	2.1	21	7.8	
2	2	7	27	79	208	2	6	+321		2.5	2.1	21	7.8	
2	2	7	27	79	208	3	5	+323		2.5	2.1	21	7.8	
2	2	7	27	79	208	3	5	+322		2.5	2.1	21	7.8	
2	2	7	27	79	208	1	5	+268	+282	2.2	2.1	17	7.6	+579
2	2	7	27	79	208	1	6	+269		2.2	2.1	17	7.6	
2	2	7	27	79	208	2	5	+289		2.2	2.1	17	7.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	LLNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTADL	TEMP	PH	LH
2	2	7	27	79	208	2	6	+239		2.2	2.1	17	7.8	
2	2	7	27	79	208	3	5	+296		2.2	2.1	17	7.8	
2	2	7	27	79	208	1	5	+177	+156	1.9	2.1	17	7.9	+460
2	2	7	27	79	208	2	5	+164		1.9	2.1	17	7.9	
2	2	7	27	79	208	3	5	+136		1.9	2.1	17	7.9	
2	2	7	27	79	208	3	4	+165		1.9	2.1	17	7.9	
2	2	12	24	79	358	1	5	+410	+408	3.1	2.1	0	5.9	+607
2	2	12	24	79	358	2	5	+406		3.1	2.1	0	5.9	
2	2	12	24	79	358	1	5	+384	+381	2.8	2.1	1	6.0	+603
2	2	12	24	79	358	2	5	+379		2.3	2.1	1	6.0	
2	2	12	24	79	358	1	5	+326	+323	2.5	2.1	2	7.8	+632
2	2	12	24	79	358	2	5	+321		2.5	2.1	2	7.3	
2	2	12	24	79	358	1	5	+244	+242	2.2	2.1	5	7.8	+549
2	2	12	24	79	358	2	5	+240		2.2	2.1	5	7.8	
2	2	12	24	79	358	1	5	+039	+037	1.9	2.1	0	7.9	+349
2	2	12	24	79	358	2	5	+034		1.9	2.1	0	7.9	
2	2	5	6	80	126	1	5	+427	+419	3.1	2.1	7	5.9	+604
2	2	5	6	80	126	2	5	+409		3.1	2.1	7	5.9	
2	2	5	6	80	126	3	5	+421		3.1	2.1	7	5.9	
2	2	5	6	80	126	1	5	+331		2.8	2.1	6	6.6	
2	2	5	6	80	126	2	5	+396	+385	2.8	2.1	6	6.0	+609
2	2	5	6	80	126	3	5	+378		2.8	2.1	6	6.0	
2	2	5	6	80	126	1	5	+322	+328	2.5	2.1	5	7.8	+635
2	2	5	6	80	126	2	5	+341		2.5	2.1	5	7.8	
2	2	5	6	80	126	3	5	+322		2.5	2.1	5	7.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHAHL	O*TABL	TEMP	PH	EH
2	2	5	6	80	126	1	5	+289	+287	2.2	2.1	5	7.8	+594
2	2	5	6	80	126	2	5	+298		2.2	2.1	5	7.8	
2	2	5	6	80	126	3	5	+274		2.2	2.1	5	7.9	
2	2	5	6	80	126	1	5	+236	+235	1.9	2.1	5	7.9	+551
2	2	5	6	80	126	2	5	+227		1.9	2.1	5	7.9	
2	2	5	6	80	126	3	5	+248		1.9	2.1	5	7.9	
2	3	6	22	79	173	1	4	+330	+336	2.5	1.8	21	6.6	+528
2	3	6	22	79	173	1	5	+331		2.5	1.8	21	6.6	
2	3	6	22	79	173	2	3	+335		2.5	1.8	21	6.6	
2	3	6	22	79	173	2	4	+336		2.5	1.8	21	6.6	
2	3	6	22	79	173	3	3	+341		2.5	1.8	21	6.6	
2	3	6	22	79	173	3	4	+341		2.5	1.8	21	6.6	
2	3	6	22	79	173	1	3	+317	+324	2.2	1.8	20	7.1	+631
2	3	6	22	79	173	1	4	+318		2.2	1.8	20	7.1	
2	3	6	22	79	173	2	3	+325		2.2	1.8	20	7.1	
2	3	6	22	79	173	2	4	+325		2.2	1.8	20	7.1	
2	3	6	22	79	173	3	3	+327		2.2	1.8	20	7.1	
2	3	6	22	79	173	3	4	+329		2.2	1.8	20	7.1	
2	3	6	22	79	173	1	3	+305	+310	1.9	1.8	18	7.4	+563
2	3	6	22	79	173	1	4	+306		1.9	1.8	18	7.4	
2	3	6	22	79	173	2	3	+312		1.9	1.8	18	7.4	
2	3	6	22	79	173	2	4	+314		1.9	1.8	18	7.4	
2	3	6	22	79	173	3	3	+309		1.9	1.8	18	7.4	
2	3	6	22	79	173	3	4	+310		1.9	1.8	18	7.4	
2	3	6	22	79	173	1	3	+211	+21[illegible]	1.6	1.8	17	7.7	+509

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
2	3	6	22	79	173	1	4	+213		1.6	1.8	17	7.7	
2	3	6	22	79	173	2	3	+221		1.6	1.9	17	7.7	
2	3	6	22	79	173	2	4	+223		1.5	1.9	17	7.7	
2	3	6	22	79	173	3	3	+220		1.6	1.8	17	7.7	
2	3	6	22	79	173	3	4	+222		1.6	1.8	17	7.7	
2	3	6	22	79	173	1	4	+200	+210	1.3	1.8	15	7.8	+509
2	3	6	22	79	173	1	5	+200		1.3	1.8	15	7.8	
2	3	6	22	79	173	2	3	+212		1.3	1.8	15	7.8	
2	3	6	22	79	173	2	4	+214		1.3	1.8	15	7.8	
2	3	6	22	79	173	3	3	+216		1.3	1.8	15	7.8	
2	3	6	22	79	173	3	4	+217		1.3	1.8	15	7.8	
2	3	7	27	79	208	1	4	+320	+332	2.5	1.8	26	6.6	+542
2	3	7	27	79	208	1	5	+324		2.5	1.8	26	6.6	
2	3	7	27	79	208	2	4	+330		2.5	1.8	26	6.6	
2	3	7	27	79	208	2	5	+331		2.5	1.8	26	6.6	
2	3	7	27	79	208	3	5	+339		2.5	1.8	26	6.6	
2	3	7	27	79	208	3	6	+337		2.5	1.8	26	6.6	
2	3	7	27	79	208	1	6	+132	+131	2.2	1.8	24	7.1	+435
2	3	7	27	79	208	1	7	+131		2.2	1.8	24	7.1	
2	3	7	27	79	208	2	5	+137		2.2	1.8	24	7.1	
2	3	7	27	79	208	2	6	+138		2.2	1.8	24	7.1	
2	3	7	27	79	208	3	5	+124		2.2	1.8	24	7.1	
2	3	7	27	79	208	3	6	+125		2.2	1.8	24	7.1	
2	3	7	27	79	208	1	5	+214	+224	1.9	1.8	21	7.4	+495
2	3	7	27	79	208	1	6	+215		1.9	1.8	21	7.4	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHAEL	D*TABL	TEMP	PH	EH
2	3	7	27	79	208	2	5	+226		1.9	1.8	21	7.4	
2	3	7	27	79	208	2	6	+226		1.9	1.8	21	7.4	
2	3	7	27	79	208	3	5	+231		1.9	1.8	21	7.4	
2	3	7	27	79	208	3	6	+232		1.9	1.8	21	7.4	
2	3	7	27	79	208	1	5	+129	+134	1.6	1.3	17	7.7	+425
2	3	7	27	79	208	1	6	+130		1.6	1.8	17	7.7	
2	3	7	27	79	208	2	4	+138		1.6	1.3	17	7.7	
2	3	7	27	79	208	2	5	+139		1.6	1.8	17	7.7	
2	3	7	27	79	208	3	5	+138		1.6	1.8	17	7.7	
2	3	7	27	79	208	3	6	+139		1.6	1.9	17	7.7	
2	3	7	27	79	208	1	5	+198	+065	1.3	1.8	17	7.8	+366
2	3	7	27	79	208	1	6	+200		1.3	1.8	17	7.8	
2	3	7	27	79	208	2	6	+011		1.3	1.8	17	7.8	
2	3	7	27	79	208	2	7	+012		1.3	1.6	17	7.8	
2	3	7	27	79	208	3	1	-093		1.3	1.8	17	7.8	
2	3	7	27	79	208	3	2	-110		1.3	1.9	17	7.8	
2	3	7	27	79	208	3	5	+170		1.3	1.8	17	7.8	
2	3	7	27	79	208	3	6	+174		1.3	1.6	17	7.8	
2	3	12	24	79	358	1	5	+352	+349	2.5	1.7	0	6.6	+577
2	3	12	24	79	358	2	5	+346		2.5	1.7	0	6.6	
2	3	12	24	79	358	1	5	+307	+304	2.2	1.7	1	7.1	+573
2	3	12	24	79	358	2	5	+300		2.2	1.7	1	7.1	
2	3	12	24	79	358	1	5	+283	+292	1.9	1.7	2	7.4	+576
2	3	12	24	79	358	2	5	+280		1.9	1.7	2	7.4	
2	3	12	24	79	358	1	5	+042	+046	1.6	1.7	5	7.7	+347

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	3	12	24	79	358	2	5	+048		1.6	1.7	5	7.7	
2	3	12	24	79	358	1	5	-040	-036	1.3	1.7	6	7.8	+270
2	3	12	24	79	358	2	5	-031		1.3	1.7	6	7.8	
2	3	5	6	80	126	1	5	+284	+286	2.5	2.1	7	6.6	+508
2	3	5	6	80	126	2	5	+278		2.5	2.1	7	6.6	
2	3	5	6	80	126	3	5	+297		2.5	2.1	7	6.6	
2	3	5	6	80	126	1	5	+334	+322	2.2	2.1	6	7.1	+533
2	3	5	6	80	126	2	5	+321		2.2	2.1	6	7.1	
2	3	5	6	80	126	3	5	+310		2.2	2.1	6	7.1	
2	3	5	6	80	126	1	5	+114	+116	1.9	2.1	5	7.4	+399
2	3	5	6	80	126	2	5	+118		1.9	2.1	5	7.4	
2	3	5	6	80	126	3	5	+115		1.9	2.1	5	7.4	
2	3	5	6	80	126	1	5	-130	-125	1.6	2.1	5	7.7	+177
2	3	5	6	80	126	2	5	-128		1.6	2.1	5	7.7	
2	3	5	6	80	126	3	5	-117		1.6	2.1	5	7.7	
2	3	5	6	80	126	1	1	-110	-120	1.3	2.1	5	7.8	+137
2	3	5	6	80	126	1	5	+180		1.3	2.1	5	7.8	
2	3	5	6	80	126	2	1	-120		1.3	2.1	5	7.8	
2	3	5	6	80	126	2	5	+176		1.3	2.1	5	7.8	
2	3	5	6	80	126	3	1	-130		1.3	2.1	5	7.8	
2	3	5	6	80	126	3	5	+190		1.3	2.1	5	7.8	
2	4	6	22	79	173	1	5	+208	+284	2.7	2.2	20	7.7	+374
2	4	6	22	79	173	1	6	+210		2.7	2.2	20	7.7	
2	4	6	22	79	173	2	5	+313		2.7	2.2	20	7.7	
2	4	6	22	79	173	2	6	+315		2.7	2.2	20	7.7	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	4	6	22	79	173	3	4	+329		2.7	2.2	20	7.7	
2	4	6	22	79	173	3	5	+330		2.7	2.2	20	7.7	
2	4	6	22	79	173	1	5	+253	+249	2.4	2.2	17	7.7	+540
2	4	6	22	79	173	1	6	+254		2.4	2.2	17	7.7	
2	4	6	22	79	173	2	6	+257		2.4	2.2	17	7.7	
2	4	6	22	79	173	2	5	+255		2.4	2.2	17	7.7	
2	4	6	22	79	173	3	5	+235		2.4	2.2	17	7.7	
2	4	6	22	79	173	3	6	+237		2.4	2.2	17	7.7	
2	4	6	22	79	173	1	4	+230	+197	2.1	2.2	16	7.7	+490
2	4	6	22	79	173	1	5	+229		2.1	2.2	16	7.7	
2	4	6	22	79	173	2	3	+236		2.1	2.2	16	7.7	
2	4	6	22	79	173	2	4	+237		2.1	2.2	16	7.7	
2	4	6	22	79	173	3	3	+121		2.1	2.2	16	7.7	
2	4	6	22	79	173	3	4	+127		2.1	2.2	16	7.7	
2	4	6	22	79	173	1	4	+136	+066	1.8	2.2	16	7.8	+365
2	4	6	22	79	173	1	5	+134		1.8	2.2	16	7.8	
2	4	6	22	79	173	2	5	-071		1.8	2.2	16	7.8	
2	4	6	22	79	173	2	6	-069		1.8	2.2	16	7.8	
2	4	6	22	79	173	3	3	+133		1.8	2.2	16	7.8	
2	4	6	22	79	173	3	4	+134		1.8	2.2	16	7.8	
2	4	6	22	79	173	1	3	+031	+060	1.3	2.2	16	7.8	+359
2	4	6	22	79	173	1	4	+041		1.3	2.2	16	7.8	
2	4	6	22	79	173	2	3	+048		1.3	2.2	16	7.8	
2	4	6	22	79	173	2	4	+047		1.3	2.2	16	7.8	
2	4	6	22	79	173	3	4	+098		1.3	2.2	16	7.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNC	TIMEMIN	ECAL	AVECAL	DEHABL	DNIADL	TEMP	PH	EH
2	4	7	27	79	208	1	1	-350	-223	1.3	1.8	17	7.8	+074
2	4	7	27	79	208	1	5	-163		1.3	1.8	17	7.8	
2	4	7	27	79	208	1	6	-107		1.3	1.8	17	7.8	
2	4	7	27	79	208	2	1	-435		1.3	1.8	17	7.8	
2	4	7	27	79	208	2	2	-327		1.3	1.3	17	7.8	
2	4	7	27	79	208	2	5	-325		1.3	1.8	17	7.6	
2	4	7	27	79	208	3	1	-128		1.3	1.8	17	7.8	
2	4	7	27	79	208	3	4	-057		1.3	1.8	17	7.8	
2	4	7	27	79	208	3	5	-055		1.3	1.8	17	7.8	
2	4	12	24	79	358	1	5	+473	+472	2.7	1.8	0	7.7	+777
2	4	12	24	79	358	2	5	+471		2.7	1.8	0	7.7	
2	4	12	24	79	358	1	5	+410	+414	2.4	1.8	1	7.7	+719
2	4	12	24	79	358	2	5	+418		2.4	1.8	1	7.7	
2	4	12	24	79	358	1	5	+391	+394	2.1	1.8	2	7.7	+697
2	4	12	24	79	358	2	5	+393		2.1	1.3	2	7.7	
2	4	12	24	79	358	1	5	+196	+194	1.8	1.8	5	7.6	+500
2	4	12	24	79	358	2	5	+191		1.8	1.8	5	7.8	
2	4	12	24	79	358	1	5	+071	+073	1.3	1.8	6	7.8	+379
2	4	12	24	79	358	2	5	+077		1.3	1.8	6	7.8	
2	4	5	6	80	126	1	5	+244	+238	2.7	1.8	7	7.7	+543
2	4	5	6	80	126	2	5	+231		2.7	1.8	7	7.7	
2	4	5	6	80	126	3	5	+238		2.7	1.8	7	7.7	
2	4	5	6	80	126	1	5	+240	+239	2.4	2.3	6	7.7	+539
2	4	5	6	80	126	2	5	+230		2.4	2.3	6	7.7	
2	4	5	6	80	126	3	5	+246		2.4	2.3	6	7.7	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	4	6	22	79	173	3	5	+097		1.3	2.2	16	7.8	
2	4	7	27	79	208	1	4	+311	+310	2.7	1.8	26	7.7	+592
2	4	7	27	79	208	1	5	+312		2.7	1.8	26	7.7	
2	4	7	27	79	208	2	4	+310		2.7	1.8	26	7.7	
2	4	7	27	79	208	2	5	+311		2.7	1.8	26	7.7	
2	4	7	27	79	208	3	4	+308		2.7	1.8	26	7.7	
2	4	7	27	79	208	3	5	+307		2.7	1.8	26	7.7	
2	4	7	27	79	208	1	4	+307	+298	2.4	1.8	24	7.7	+585
2	4	7	27	79	208	1	5	+309		2.4	1.8	24	7.7	
2	4	7	27	79	208	2	5	+324		2.4	1.8	24	7.7	
2	4	7	27	79	208	2	6	+326		2.4	1.8	24	7.7	
2	4	7	27	79	208	3	8	+259		2.4	1.8	24	7.7	
2	4	7	27	79	208	3	9	+200		2.4	1.8	24	7.7	
2	4	7	27	79	208	1	6	+110	+057	2.1	1.8	21	7.7	+346
2	4	7	27	79	208	1	7	+111		2.1	1.8	21	7.7	
2	4	7	27	79	208	2	5	-006		2.1	1.8	21	7.7	
2	4	7	27	79	208	2	6	-008		2.1	1.8	21	7.7	
2	4	7	27	79	208	3	5	+006		2.1	1.8	21	7.7	
2	4	7	27	79	208	3	6	+007		2.1	1.8	21	7.7	
2	4	7	27	79	208	1	6	+094	+011	1.8	1.8	17	7.8	+308
2	4	7	27	79	208	1	7	+095		1.8	1.8	17	7.8	
2	4	7	27	79	208	2	6	+004		1.8	1.8	17	7.8	
2	4	7	27	79	208	2	7	+006		1.8	1.8	17	7.8	
2	4	7	27	79	208	3	5	+013		1.8	1.8	17	7.8	
2	4	7	27	79	208	3	6	+019		1.8	1.8	17	7.8	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	4	5	6	80	126	1	1	-040	-043	2.1	2.3	5	7.7	+256
2	4	5	6	80	126	1	5	+240		2.1	2.3	5	7.7	
2	4	5	6	80	126	2	1	-054		2.1	2.3	5	7.7	
2	4	5	6	80	126	2	5	+240		2.1	2.3	5	7.7	
2	4	5	6	80	126	3	1	-036		2.1	2.3	5	7.7	
2	4	5	6	80	126	3	5	+240		2.1	2.3	5	7.7	
2	4	5	6	80	126	1	1	-010	-023	1.8	2.3	5	7.8	+294
2	4	5	6	80	126	1	5	+204		1.8	2.3	5	7.8	
2	4	5	6	80	126	2	1	-040		1.8	2.3	5	7.8	
2	4	5	6	80	126	2	5	+204		1.8	2.3	5	7.8	
2	4	5	6	80	126	3	1	-020		1.8	2.3	5	7.8	
2	4	5	6	80	126	3	5	+204		1.8	2.3	5	7.8	
2	4	5	6	80	126	1	1	+000	-001	1.3	2.3	5	7.8	+305
2	4	5	6	80	126	1	5	+200		1.3	2.3	5	7.8	
2	4	5	6	80	126	2	1	+020		1.3	2.3	5	7.8	
2	4	5	6	80	126	2	5	+200		1.3	2.3	5	7.8	
2	4	5	6	80	126	3	1	-010		1.3	2.3	5	7.8	
2	4	5	6	80	126	3	5	+200		1.3	2.3	5	7.8	
2	5	6	22	79	173	1	3	+285	+304	2.1	1.9	20	7.6	+587
2	5	6	22	79	173	1	4	+287		2.1	1.9	20	7.6	
2	5	6	22	79	173	2	5	+308		2.1	1.9	20	7.6	
2	5	6	22	79	173	2	6	+309		2.1	1.9	20	7.6	
2	5	6	22	79	173	3	6	+317		2.1	1.9	20	7.6	
2	5	6	22	79	173	3	7	+319		2.1	1.9	20	7.6	
2	5	6	22	79	173	1	3	+157	+152	1.9	1.9	18	7.7	+442

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	5	6	22	79	173	1	4	+155		1.9	1.9	18	7.7	
2	5	6	22	79	173	2	3	+155		1.9	1.9	18	7.7	
2	5	6	22	79	173	2	4	+157		1.9	1.9	18	7.7	
2	5	6	22	79	173	3	3	+143		1.9	1.9	18	7.7	
2	5	6	22	79	173	3	4	+148		1.9	1.9	18	7.7	
2	5	6	22	79	173	1	8	+121	+082	1.6	1.9	17	7.7	+373
2	5	6	22	79	173	1	9	+122		1.6	1.9	17	7.7	
2	5	6	22	79	173	2	3	+106		1.6	1.9	17	7.7	
2	5	6	22	79	173	2	4	+107		1.6	1.9	17	7.7	
2	5	6	22	79	173	3	3	+035		1.6	1.9	17	7.7	
2	5	6	22	79	173	3	4	+039		1.6	1.9	17	7.7	
2	5	6	22	79	173	3	5	+041		1.6	1.9	17	7.7	
2	5	6	22	79	173	1	4	+108	-060	1.3	1.9	15	7.6	+228
2	5	6	22	79	173	1	5	+106		1.3	1.9	15	7.6	
2	5	6	22	79	173	2	3	+087		1.3	1.9	15	7.6	
2	5	6	22	79	173	2	4	+089		1.3	1.9	15	7.6	
2	5	6	22	79	173	3	2	-581		1.3	1.9	15	7.6	
2	5	6	22	79	173	3	3	-575		1.3	1.9	15	7.6	
2	5	6	22	79	173	1	5	-058	-059	1.0	2.1	15	7.6	+224
2	5	6	22	79	173	1	6	-060		1.0	2.1	15	7.6	
2	5	6	22	79	173	2	8	+039		1.0	2.1	15	7.6	
2	5	6	22	79	173	2	9	+060		1.0	2.1	15	7.6	
2	5	6	22	79	173	3	5	+058		1.0	2.1	15	7.6	
2	5	6	22	79	173	3	6	+060		1.0	2.1	15	7.6	
2	5	7	27	79	208	1	5	+286	+256	2.1	2.0	26	7.6	+537

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNC	TIMEMIN	ECAL	AVECAL	DEHABL	D*TABL	TEMP	PH	EH
2	5	7	27	79	208	1	6	+238		2.1	2.0	26	7.6	
2	5	7	27	79	208	2	5	+314		2.1	2.0	26	7.6	
2	5	7	27	79	208	2	6	+315		2.1	2.0	26	7.6	
2	5	7	27	79	208	3	5	+310		2.1	2.0	26	7.6	
2	5	7	27	79	208	3	6	+311		2.1	2.0	26	7.6	
2	5	7	27	79	208	1	5	+113	+107	1.9	2.0	24	7.7	+393
2	5	7	27	79	208	1	6	+114		1.9	2.0	24	7.7	
2	5	7	27	79	208	2	4	+083		1.9	2.0	24	7.7	
2	5	7	27	79	208	2	5	+086		1.9	2.0	24	7.7	
2	5	7	27	79	208	3	6	+123		1.9	2.0	24	7.7	
2	5	7	27	79	208	3	7	+125		1.9	2.0	24	7.7	
2	5	7	27	79	208	1	3	+119	+119	1.6	2.0	21	7.7	+408
2	5	7	27	79	208	1	4	+117		1.6	2.0	21	7.7	
2	5	7	27	79	208	2	4	+117		1.6	2.0	21	7.7	
2	5	7	27	79	208	2	5	+118		1.6	2.0	21	7.7	
2	5	7	27	79	208	3	5	+121		1.6	2.0	21	7.7	
2	5	7	27	79	208	3	6	+122		1.6	2.0	17	7.6	
2	5	7	27	79	208	1	4	+022	+036	1.3	2.0	17	7.6	+321
2	5	7	27	79	208	1	5	+023		1.3	2.0	17	7.6	
2	5	7	27	79	208	2	4	+004		1.3	2.0	17	7.6	
2	5	7	27	79	208	2	5	+004		1.3	2.0	17	7.6	
2	5	7	27	79	208	3	6	+031		1.3	2.0	17	7.6	
2	5	7	27	79	208	3	9	+081		1.3	2.0	17	7.6	
2	5	7	27	79	208	1	4	-058	-077	1.0	2.0	17	7.6	+208
2	5	7	27	79	208	1	5	-064		1.0	2.0	17	7.6	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	5	7	27	79	208	2	6	-074		1.0	2.0	17	7.6	
2	5	7	27	79	208	2	7	-087		1.0	2.0	17	7.6	
2	5	7	27	79	208	3	5	-084		1.0	2.0	17	7.6	
2	5	7	27	79	208	3	6	-089		1.0	2.0	17	7.6	
2	5	12	24	79	358	1	5	+345	+346	2.1	1.8	0	7.6	+645
2	5	12	24	79	358	2	5	+337		2.1	1.8	0	7.5	
2	5	12	24	79	358	1	5	+291	+294	1.9	1.8	1	7.7	+598
2	5	12	24	79	358	2	5	+296		1.9	1.8	1	7.7	
2	5	12	24	79	358	1	5	+210	+209	1.6	1.8	2	7.7	+512
2	5	12	24	79	358	2	5	+207		1.6	1.8	2	7.7	
2	5	12	24	79	358	1	5	+134	+125	1.3	1.8	5	7.6	+413
2	5	12	24	79	358	2	5	+116		1.3	1.8	5	7.6	
2	5	12	24	79	358	1	5	+109	+108	1.0	1.8	6	7.6	+402
2	5	12	24	79	358	2	5	+107		1.0	1.8	6	7.6	
2	5	12	24	79	358	1	5	+108	+108	2.1	1.8	7	7.6	+402
2	5	5	6	80	126	2	5	+184	+168	2.1	1.8	7	7.6	+461
2	5	5	6	80	126	3	5	+152		2.1	1.8	7	7.6	
2	5	5	6	80	126	1	5	+020	+023	1.9	2.0	7	7.7	+321
2	5	5	6	80	126	2	5	+010		1.9	2.0	7	7.7	
2	5	5	6	80	126	3	5	+040		1.9	2.0	7	7.7	
2	5	5	6	80	126	1	1	-084	-081	1.6	2.0	6	7.7	+209
2	5	5	6	80	126	2	1	-092		1.6	2.0	6	7.7	
2	5	5	6	80	126	3	1	-078		1.6	2.0	6	7.7	
2	5	5	6	80	126	3	5	+160		1.6	2.0	6	7.7	
2	5	5	6	80	126	1	5	-076	-080	1.3	2.0	5	7.6	+215

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	D.TABL	TEMP	PH	Eh
2	5	5	6	80	126	2	5	-052		1.3	2.0	5	7.6	
2	5	5	6	80	126	3	5	-084		1.3	2.0	5	7.6	
2	5	5	6	80	126	1	5	-080	-087	1.0	2.0	5	7.6	+209
2	5	5	6	80	126	2	5	-041		1.0	2.0	5	7.6	
2	5	5	6	80	126	3	5	-096		1.0	2.0	5	7.6	
2	6	6	22	79	173	1	4	-058	-084	1.7	1.7	19	7.2	+177
2	6	6	22	79	173	1	5	-059		1.7	1.7	19	7.2	
2	6	6	22	79	173	2	4	-066		1.7	1.7	19	7.2	
2	6	6	22	79	173	2	5	-072		1.7	1.7	19	7.2	
2	6	6	22	79	173	3	5	-121		1.7	1.7	19	7.2	
2	6	6	22	79	173	3	6	-147		1.7	1.7	19	7.2	
2	6	6	22	79	173	1	4	-064	-088	1.4	1.7	18	7.2	+172
2	6	6	22	79	173	1	5	-097		1.4	1.7	18	7.2	
2	6	6	22	79	173	2	6	-021		1.4	1.7	18	7.2	
2	6	6	22	79	173	2	7	-028		1.4	1.7	18	7.2	
2	6	6	22	79	173	3	8	-184		1.4	1.7	18	7.2	
2	6	6	22	79	173	3	9	-141		1.4	1.7	18	7.2	
2	6	6	22	79	173	1	1	-147	-171	1.1	1.7	17	7.2	+091
2	6	6	22	79	173	1	2	-110		1.1	1.7	17	7.2	
2	6	6	22	79	173	1	6	+190		1.1	1.7	17	7.2	
2	6	6	22	79	173	2	4	-187		1.1	1.7	17	7.2	
2	6	6	22	79	173	2	5	-108		1.1	1.7	17	7.2	
2	6	6	22	79	173	2	9	+180		1.1	1.7	17	7.2	
2	6	6	22	79	173	3	5	-178		1.1	1.7	17	7.2	
2	6	6	22	79	173	3	6	-198		1.1	1.7	17	7.2	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	6	6	22	79	173	3	9	+110		1.1	1.7	17	7.2	
2	6	6	22	79	173	1	5	-147	-168	0.8	1.7	16	7.1	+039
2	6	6	22	79	173	2	5	-184		0.8	1.7	16	7.1	
2	6	6	22	79	173	3	5	-172		0.8	1.7	16	7.1	
2	6	6	22	79	173	3	9	+210		0.8	1.7	16	7.1	
2	6	6	22	79	173	1	5	-162	-219	0.5	1.7	15	7.2	+045
2	6	6	22	79	173	2	5	-196		0.5	1.7	15	7.2	
2	6	6	22	79	173	3	5	-280		0.5	1.7	15	7.2	
2	6	7	27	79	208	1	5	-136	-134	1.7	1.6	26	7.2	+123
2	6	7	27	79	208	1	6	-135		1.7	1.6	26	7.2	
2	6	7	27	79	208	2	5	-144		1.7	1.6	26	7.2	
2	6	7	27	79	208	2	6	-143		1.7	1.6	26	7.2	
2	6	7	27	79	208	3	5	-121		1.7	1.6	26	7.2	
2	6	7	27	79	208	3	6	-123		1.7	1.6	26	7.2	
2	6	7	27	79	208	1	1	-322	-206	1.4	1.6	24	7.2	+051
2	6	7	27	79	208	1	5	-211		1.4	1.6	24	7.2	
2	6	7	27	79	208	1	6	-241		1.4	1.6	24	7.2	
2	6	7	27	79	208	2	5	-208		1.4	1.6	24	7.2	
2	6	7	27	79	208	2	6	-207		1.4	1.6	24	7.2	
2	6	7	27	79	208	3	5	-200		1.4	1.6	24	7.2	
2	6	7	27	79	208	3	6	-201		1.4	1.6	24	7.2	
2	6	7	27	79	208	1	5	-213	-255	1.1	1.6	21	7.2	+004
2	6	7	27	79	208	1	7	-215		1.1	1.6	21	7.2	
2	6	7	27	79	208	2	4	-289		1.1	1.6	21	7.2	
2	6	7	27	79	208	2	5	-290		1.1	1.6	21	7.2	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	ECAL	AVECAL	DCHAOL	DWTABL	TEMP	pH	EH
2	6	7	27	79	208	3	4	-264		1.1	1.6	21	7.2	
2	6	7	27	79	208	3	5	-263		1.1	1.6	21	7.2	
2	6	7	27	79	208	1	4	-135	-044	0.8	1.6	17	7.1	+212
2	6	7	27	79	208	1	5	-133		0.8	1.6	17	7.1	
2	6	7	27	79	208	2	5	-047		0.8	1.6	17	7.1	
2	6	7	27	79	208	2	6	-045		0.8	1.6	17	7.1	
2	6	7	27	79	208	3	5	-045		0.8	1.6	17	7.1	
2	6	7	27	79	208	3	4	-044		0.8	1.6	17	7.1	
2	6	7	27	79	208	1	1	-230	-041	0.5	1.6	17	7.2	+221
2	6	7	27	79	208	1	5	-124		0.5	1.6	17	7.2	
2	6	7	27	79	208	1	6	-128		0.5	1.6	17	7.2	
2	6	7	27	79	208	2	1	-143		0.5	1.6	17	7.2	
2	6	7	27	79	208	2	5	-092		0.5	1.6	17	7.2	
2	6	7	27	79	208	2	6	-090		0.5	1.6	17	7.2	
2	6	7	27	79	208	3	1	-134		0.5	1.6	17	7.2	
2	6	7	27	79	208	3	5	-068		0.5	1.6	17	7.2	
2	6	7	27	79	208	3	6	-066		0.5	1.6	17	7.2	
2	6	12	24	79	358	1	5	-147	-151	1.7	1.6	0	7.2	+124
2	6	12	24	79	358	2	5	-154		1.7	1.6	0	7.2	
2	6	12	24	79	358	1	5	-161	-166	1.4	1.6	1	7.2	+109
2	6	12	24	79	358	2	5	-172		1.4	1.6	1	7.1	
2	6	12	24	79	358	1	5	-164	-171	1.1	1.6	2	7.2	+103
2	6	12	24	79	358	2	5	-178		1.1	1.6	2	7.2	
2	6	12	24	79	358	1	5	-185	-189	0.8	1.6	5	7.2	+083
2	6	12	24	79	358	2	5	-192		0.8	1.6	5	7.2	

TRV	SS	MONTH	DAY	YEAR	DAYYEAR	ELNO	TIMEMIN	LCAL	AVECAL	DEHABL	DWTABL	TEMP	PH	EH
2	6	12	24	79	358	1	5	-241	-232	0.5	1.6	6	7.2	+038
2	6	12	24	79	358	2	5	-224		0.5	1.6	6	7.2	
2	6	12	24	79	358	2	5	+170		0.5	1.6	6	7.2	
2	6	5	6	80	126	1	1	-157	-151	1.7	2.3	7	7.2	+118
2	6	5	6	80	126	2	1	-146		1.7	2.3	7	7.2	
2	6	5	6	80	126	3	5	+210		1.7	2.3	7	7.2	
2	6	5	6	80	126	1	1	-187	-181	1.4	2.3	7	7.1	+082
2	6	5	6	80	126	2	1	-172		1.4	2.3	7	7.1	
2	6	5	6	80	126	3	1	-184		1.4	2.3	7	7.1	
2	6	5	6	80	126	3	2	+100		1.4	2.3	7	7.1	
2	6	5	6	80	126	1	1	-184	-115	1.1	2.3	6	7.2	+156
2	6	5	6	80	126	2	1	-154		1.1	2.3	6	7.2	
2	6	5	6	80	126	3	1	-110		1.1	2.3	6	7.2	
2	6	5	6	80	126	3	2	+010		1.1	2.3	6	7.2	

Supplement

TRV	SS	MONTH	DAY	YEAR	DAY/YEAR	ELNO	TIME/MIN	ECALB[a]	AVE/CAL	DEHABL	EH
2	3	6	22	79	173	1	0	-140	-142	1.9	+126
2	3	6	22	79	173	2	0	-167			
2	3	6	22	79	173	3	0	-120			
2	3	6	22	79	173	1	0	-087	-083	1.6	+203
2	3	6	22	79	173	2	0	-088			
2	3	6	22	79	173	3	0	-074			
2	3	6	22	79	173	1	0	+057	+063	1.3	+355
2	3	6	22	79	173	2	0	+074			
2	3	6	22	79	173	3	0	+060			
2	3	7	27	79	208	1	0	-093	-102	1.3	+184
2	3	7	27	79	208	2	0	-110			
2	3	7	27	79	208	3	0	-105			
2	4	6	22	79	173	1	0	-084	-097	2.1	+188
2	4	6	22	79	173	2	0	-098			
2	4	6	22	79	173	3	0	-110			
2	4	6	22	79	173	3	0	-084	-086	1.8	+206
2	4	6	22	79	173	3	0	-097			
2	4	6	22	79	173	3	0	-078			

[a]ECALB is the beginning ECAL measurement.